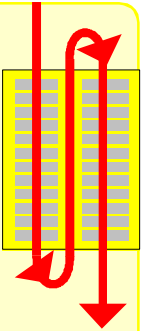
# Instructions



Scrolling through a two-column document on-screen from the bottom of one column to the top of the next, and so on, can get very tedious. Fortunately, “column threading” is automatic with this software. Here are the basic tools and techniques that you need to know to efficiently navigate through the columns in this document …

1. Click on the hand tool in the button bar. 

2. Whenever the hand cursor is positioned over a column, the cursor changes to the “read article cursor”,  and “Read Article” appears in the status bar to indicate that this text is part of an “article”. *An article is a collection of columns selected by the editor that comprise one subject, like one of the articles on the front page of a newspaper. Each first-level section (1.1, 1.2, 1.3…) of the NTIA Manual has been defined as a separate article.*
   Click any part of the article to start reading at that point, or control-click to start at the beginning of the article. The cursor now changes to the follow-article cursor, and “Follow Article” appears in the status bar.



3. To page down, simply click the mouse, or use the scrollbar, or press the PageDown key. *You can keep track of where you are on the page if you're using the thumbnails-and-page view. In this view a selection rectangle moves over a thumbnail of the page as you scroll through the columns in the page view window.*

4. You can continue to click until you reach the end of the article. At the end of the article, the cursor changes to the end-article cursor, and "End Article" appears in the status bar. Click again to return to the page view displayed before you started reading the article. Click the fit page button.

5. If you want to exit before the end of the article…
   - select any navigation method (but not Enter or Return)
   - Go to another article or page
   - Hold down Shift + Ctrl and click.



6. You can also select which article (NTIA Manual Section) to view by choosing “Articles…” from the View menu, and then selecting the article you want from the dialog box that appears. *You can keep this dialog box displayed so you can go from one article to an better yet, use the bookmarks method described in #7 below.*

7. The best way to select which article (NTIA Manual Section) to view is to switch to the “Bookmarks-and-Page” view, click on the section name bookmark, click with the hand cursor on the page, then navigate with the hand tool as described in #1-5 above. Links to all of the sections are provided — as well as links to tables, figures, endnotes, and even these instructions.

8. To select text within a column, click the text selection tool, hold down the Control key, and drag to select the text you want to copy.

**CHAPTER 5**

# Spectrum Standards

## 5.0. GENERAL

This chapter contains Radio Frequency Spectrum Standards applicable to Federal radio stations and systems.

A radio frequency spectrum standard is a principle, rule, or criterion that bounds the spectrum-related parameters, and characteristics, of a radio station or system for the purpose of managing the Radio Frequency Spectrum. Application of spectrum standards include:

(a) assisting consideration of telecommunications systems for the National spectrum review process (Chapter 10),

(b) systems planning, design, and procurement.

(c) Consideration of protection devices for the transmission of classified, and/or sensitive but unclassified information, and their spectrum needs.

The standards contained herein are those associated with the potential impact of any system or station on the normal operation of other systems or stations.

If spectrum standards are not specified in this chapter, the appropriate provisions of the ITU Radio Regulations normally shall apply. If spectrum standards are not specified in this chapter or in the ITU Radio Regulations, the appropriate criteria contained in current Recommendations of the CCIR shall be used as guidelines.

Compliance with standards contained in this chapter may not preclude the occurrence of interference. Therefore, compliance with the standards does not obviate the need for cooperation in resolving and implementing engineering solutions to harmful interference problems (see Section 2.3.7)

### 5.0.1 Consequences of Nonconformance with the Provisions of this Chapter

In any instance of harmful interference caused by nonconformance with the provisions of this chapter, the responsibility for eliminating the harmful interference normally shall rest with the agency operating in nonconformance.

### 5.0.2 Agency Procurement Specifications

Procurement specifications shall, as a minimum, assure compliance with the appropriate requirements of this chapter. Agencies may promulgate more stringent criteria for their own use.

### 5.0.3 Measurement Methods

Measurement methods included or referenced in this chapter are provided only for clarification and uniform interpretation of the standards. In cases of harmful interference, the agencies involved are expected to utilize these or equivalent, mutually agreed upon, methods of measurement for resolution of any disagreement concerning compliance with the standards. Agencies may, at their discretion, use these measurement methods as minimum qualification test procedures, e.g., as part of factory test procedures.

### 5.0.4 Terminology

Definitions of Special Terms, Services, and Stations are contained in Chapter 6.

**Desired Relationship of Occupied Bandwidth to Necessary Bandwidth**

The emission designator(s) associated in the authorization for any particular frequency assignment specifies the value of the necessary bandwidth of emission for the particular type(s) of transmission permitted. The values of necessary bandwidth are generally idealized. All reasonable effort shall be made in equipment design and operation by Government agencies to maintain the occupied bandwidth of the emission of any authorized transmission as close to the necessary bandwidth as is reasonably practicable. (See Annex J for additional information concerning necessary bandwidth.)

### Resolution Bandwidth

Resolution bandwidth is the 3 dB bandwidth of the measurement system used, e.g., in power spectral density measurements. The appropriate resolution bandwidth of the measurement system varies depending on the modulation type and frequency band but should not be greater than the necessary bandwidth of the transmitter being measured.

### Power (RR)

Power is designated as:
peak envelope power (PX or pX)
mean power (PY or pY)
carrier power (PZ or pZ)
p denotes power expressed in watts
P denotes power in dB relative to a reference level

### Logarithm

In this chapter, Log=$\text{Log}_{10}$

### Frequency Tolerances

Transmitter frequency tolerance is the maximum permissible departure from the assigned frequency by the center frequency of the frequency band occupied by an emission.

Receiver frequency tolerance is the maximum permissible departure of the center frequency of the IF passband from the desired center frequency of the IF passband.

The frequency tolerance is expressed in parts per million (ppm).

## 5.0.5 Specific Standards

Where specific standards are provided in this chapter, the frequency tolerances and levels of unwanted emissions in these specific standards take precedence over the values in the Table in Part 5.1.

## 5.1 TABLE OF FREQUENCY TOLERANCES AND UNWANTED EMISSIONS

| Frequency Bands and Station Type | Levels of Unwanted Emissions | Frequency Tolerance |
|---|---|---|
| **BAND: 9 to 535 kHz** | | |
| 1. Fixed Stations | | |
| 1.1 9-50 kHz | A | 100 |
| 1.2 50-535 kHz | A | 50 |

| Frequency Bands and Station Type | Levels of Unwanted Emissions | Frequency Tolerance |
|---|---|---|
| 2. Land Stations | | |
| 2.1 Coast Stations | A | 100 |
| 2.1.1 Direct printing telegraphy and data | A | 10 Hz (aa) |
| 2.2 Aeronautical Stations | A | 50 |
| 2.3 Base Stations (TIS) | A | 100 Hz |
| 3. Mobile Stations | | |
| 3.1 Ship Stations | A | 200 |
| 3.1.1 Direct printing telegraphy and data | A | 10 Hz (bb) |
| 3.2 Ship Emergency Transmitters | A | 500 (a) |
| 3.3 Survival Craft | A | 500 |
| 3.4 Aircraft Stations | A | 50 |
| 3.5 Land Mobile | A | 20 |
| 4. Radionavigation Stations | A | 100 |
| 5. Radiolocation Stations | A | 100 |
| **BAND: 535 to 1605 kHz** | | |
| 1. Broadcasting Stations | A | 10 Hz (b) |
| **BAND: 1605 to 4000 kHz** | | |
| 1. Fixed Stations | | |
| 1.1 Other than SSB | A | 10 |
| 1.2 SSB Radiotelephone | B | 20 Hz |
| 2. Land Stations | | |
| 2.1 Coast Stations | | |
| 2.1.1 200 W or less, other than SSB | A | 100 |
| 2.1.2 Above 200 W, other than SSB | A | 50 |
| 2.1.3 SSB radiotelephone | B | 20 Hz |
| 2.1.4 Direct printing telegraphy and data | B | 10 Hz (aa) |
| 2.2 Aeronautical Stations | | |
| 2.2.1 200 W or less, other than SSB | A | 20 |
| 2.2.2 Above 200 W, other than SSB | A | 10 |
| 2.2.3 SSB radiotelephone | B | 10 Hz (c) |
| 2.3 Base Stations | | |
| 2.3.1 200 W or less, other than SSB | A | 20 (d) |
| 2.3.2 Above 200 W, other than SSB | A | 10 |
| 2.3.3 SSB radiotelephone | B | 20 Hz |
| 3. Mobile Stations | | |
| 3.1 Ship Stations | | |
| 3.1.1 SSB radiotelephone | B | 40 Hz (e) |
| 3.1.2 Other than SSB | A | 40 (f)(g) |
| 3.1.3 Direct print telegraphy and data | B | 40 Hz |
| 3.2 Survival Craft Stations | A | 100 (h) |
| 3.2.1 Emergency position indicating radiobeacons | A | 100 (i) |
| 3.3 Aircraft Stations | | |
| 3.3.1 SSB radiotelephone | B | 20 Hz (j) |
| 3.3.2 Other than SSB | A | 20 |
| 3.4 Land Mobile Stations | | |
| 3.4.1 SSB radiotelephone | B | 20 Hz |
| 3.4.2 Other than SSB | A | 50 |
| 4. Radionavigation Stations | | |
| 4.1 Under 200 W | A | 20 |
| 4.2 200 W and above | A | 10 |
| 5. Radiolocation Stations | A | 10 |

| Frequency Bands and Station Type | Levels of Unwanted Emissions | Frequency Tolerance |
|---|---|---|
| 6. Broadcasting Stations | A | 10 Hz |
| **BAND: 4 to 29.7 MHz** | | |
| 1. Fixed Stations | | |
| 1.1 500 W or less, other than SSB/ISB | A | 20 (k) |
| 1.2 Above 500 W, other than SSB/ISB | A | 10 |
| 1.3 SSB/ISB Radiotelephone | B | 20 Hz |
| 1.4 Class F1B Emissions | A | 10 Hz |
| 2. Land Stations | | |
| 2.1 Coast Stations | | |
| 2.1.1 500 W or less | A | 20Hz(l)(cc) |
| 2.1.2 500 W to 5 kW | A | 20Hz(l)(dd) |
| 2.1.3 Above 5 kW | A | 20Hz(ee) |
| 2.1.4 SSB radiotelephone | B | 20Hz |
| 2.1.5 Direct printing telegraphy and data | B | 10Hz(aa) |
| 2.2 Aeronautical Stations | | |
| 2.2.1 500 W or less, other than SSB | A | 30 |
| 2.2.2 Above 500 W, other than SSB | A | 10 |
| 2.2.3 SSB radiotelephone | B | 10 Hz (c) |
| 2.3 Base Stations | | |
| 2.3.1 500 W or less, other than SSB | A | 20 (k) |
| 2.3.2 Above 500 W, other than SSB | A | 10 |
| 2.3.3 SSB radiotelephone | B | 20 Hz |
| 3. Mobile Stations | | |
| 3.1 Ship Stations | | |
| 3.1.1 Class A1A Emissions | A | 10 (g) |
| 3.1.2 Other than A1A Emissions | | |
| 3.1.2.1 SSB radiotelephone | B | 50 Hz |
| 3.1.2.2 Direct printing radiotelegraphy and data | B | 10 Hz (bb) |
| 3.1.2.3 Other than above | A | 50 Hz (m) |
| 3.2 Survival Craft Stations | A | 50 (h) |
| 3.3 Aircraft Stations | | |
| 3.3.1 SSB radiotelephone | B | 20 Hz |
| 3.3.2 Other than above | A | 30 |
| 3.4 Land Mobile Stations | | |
| 3.4.1 SSB radiotelephone | B | 20 Hz |
| 3.4.2 Other than above | A | 30 |
| 4. Broadcasting Stations | A | 2 |
| 5. Earth Stations | A | 20 |
| 6. Space Stations | A | 20 |
| **BAND: 29.7 to 100 MHz** | | |
| 1. Fixed Stations | | |
| 1.1 10 W or less | D,E,B | 20 |
| 1.2 Above 10 W | D,E,B | 5 |
| 2. Land Stations | | |
| 2.1 10 W or less | D,E | 20 |
| 2.2 Above 10 W | D,E | 5 |
| 3. Mobile Stations | | |
| 3.1 10 W or less | D,E,B | 20 (n) |
| 3.2 Above 10 W | D,E,B | 5 |

| Frequency Bands and Station Type | Levels of Unwanted Emissions | Frequency Tolerance |
|---|---|---|
| 4. Radionavigation Stations | D | 50 |
| 5. Broadcasting Stations | | |
| 5.1 Other than TV | | |
| 5.1.1 10 W or less | D | 3000 Hz |
| 5.1.2 Above 10 W | D | 2000 Hz |
| 5.2 TV Sound and Vision | D | 500 Hz (o)(p)(x) |
| 6. Earth Stations | D | 20 |
| 7. Space Stations | D | 20 |
| **BAND: 100 to 470 MHz** | | |
| 1. Fixed Stations | | |
| 1.1 Band 100-406 MHz | D,E | 5 |
| 1.2 Band 162-174 MHz (Narrowband) | O | 3 |
| 1.3 Band 162-174 MHz (Splinter channels) | | |
| 1.3.1 10 W or less | D,E | 5 |
| 1.3.2 Above 10 W | D,E | 2 |
| 1.4 Band 406-470 MHz | | |
| 1.4.1 10 W or less | D,E,M | 5 (q) |
| 1.4.2 Above 10 W | D,E,M | 2.5 (q) |
| 2. Land Stations | | |
| 2.1 Coast Stations | | |
| 2.1.1 Band 150.8-162.0125 MHz | | |
| 2.1.1.1 Less than 3 W | D,E | 10 (r) |
| 2.1.1.2 Less than 100 W but greater than or equal to 3 W | D,E | 5 (r) |
| 2.1.1.3 Greater than or equal to 100 W | D,E | 2.5 (r) |
| 2.1.2 Outside band 150.8-162.0125 MHz | D,E | 10 (r) |
| 2.2 Aeronautical Stations | D,E | 20 |
| 2.3 Base Stations | | |
| 2.3.1 Band 100-406 MHz | D,E | 5 |
| 2.3.2 Band 162-174 MHz (Narrowband) | O | 3 |
| 2.3.3 Band 162-174 MHz (Splinter channels) | | |
| 2.3.3.1 10 W or less | D,E | 5 |
| 2.3.3.2 Above 10 W | D,E | 2 |
| 2.3.4 Band 406-470 MHz | | |
| 2.3.4.1 10 W or less | D,E | 5 |
| 2.3.4.2 Above 10 W | D,E | 2.5 |

| Frequency Bands and Station Type | Levels of Unwanted Emissions | Frequency Tolerance |
|---|---|---|
| 3. Mobile Stations | | |
| 3.1 Ship Stations | | |
| 3.1.1 Band 156-162 MHz | E | 10 |
| 3.1.2 Band 406-420 MHz | E | 5 (s) |
| 3.1.3 Band 450-470 MHz | D,E | 5 |
| 3.1.4 Outside above bands | D,E | 20 (t) |
| 3.2 Survival Craft Stations | | |
| 3.2.1 Band 156-162 MHz | D,E | 10 (r) |
| 3.2.2 Other than above | D,E | 20 (u) |
| 3.3 Aircraft Stations | | |
| 3.3.1 Bands 156-174 and 406-420 MHz | E | 5 (s) |
| 3.3.2 Other than above | D,E | 20 |
| 3.4 Land Mobile Stations | | |
| 3.4.1 Band 162-174 MHz | D,E | 5 (n) |
| 3.4.2 Band 162-174 MHz (Narrowband) | O | 3 |
| 3.4.2.1 Mobiles | O | 5 |
| 3.4.2.2 Portables | D,E | 2 |
| 3.4.3 Band 162-174 MHz (Splinter channels) | | |
| 3.4.3.1 10 W or less | D,E | 5 |
| 3.4.3.2 Above 10 W | D,E | 2 |
| 3.4.4 Band 406-420 MHz | D,E | 5 |
| 3.4.5 Other than above | D,E | 15 (v) |
| 4. Radionavigation Stations | | |
| 4.1 Radar | F | 50 (w) |
| 4.2 Other than above | D | 20 |
| 5. Radiolocation Stations | | |
| 5.1 Radar | F | 50 (w) |
| 5.2 Other than above | D | 50 |
| 6. Broadcasting Stations | | |
| 6.1 Other than TV | D | 2000 Hz |
| 6.2 TV Sound and Vision | D | 500 Hz(o)(p)(x) |
| 7. Earth Stations | D | 20 |
| 8. Space Stations | D | 20 |
| **BAND: 470 to 960 MHz** | | |
| 1. Fixed Stations | D,M | 5 |
| 2. Land Stations | D | 5 |
| 3. Mobile Stations | | |
| 3.1 3 W or less | D | 20 (g) |
| 3.2 Above 3 W | D | 5 |
| 4. Radiolocation Stations | | |
| 4.1 Radar | F | 400 |
| 4.2 Other than above | D | 400 |
| 5. Broadcasting Stations | | |
| 5.1 TV Broadcasting Stations | D | 500 Hz(o)(p)(x) |
| 5.2 TV Broadcasting Translator Stations | D | 200 |
| 6. Earth Stations | G,H | 20 |
| 7. Space Stations | G,H | 20 |
| **BAND: 960 to 1215 MHz** | | |
| 1. Aeronautical Radionavigation | | |
| 1.1 Land and Ship Stations | I | 10 |
| 1.2 Aircraft Stations | I | 50 |

| Frequency Bands and Station Type | Levels of Unwanted Emissions | Frequency Tolerance |
|---|---|---|
| 2. IFF/ATCRBS or Similar Type Stations | | |
| 2.1 Interrogators 1030 MHz | I | 200 kHz |
| 2.2 Transponders 1090 MHz | I | 3 MHz |
| **BAND: 1215 to 2450 MHz** | | |
| 1. Fixed Stations | | |
| 1.1 100 W or less | I,J,M | 30 |
| 1.2 Above 100 W | I,J,M | 10 |
| 2. Land Stations | I,J | 20 (k ) |
| 3. Mobile Stations | I,J | 20 (k) |
| 4. Radionavigation Stations | | |
| 4.1 Radar | F | 500 (y) |
| 4.2 Other than above | I | 500 (y) |
| 5. Radiolocation Stations | | |
| 5.1 Radar | F | 500 (y) |
| 5.2 Other than above | I | 500 (y) |
| 6. Earth Stations | N | 20 |
| 7. Space Stations | N | 20 |
| **BAND: 2450 to 4000 MHz** | | |
| 1. Fixed Stations | | |
| 1.1 100 W or less | I,M | 30 |
| 1.2 Above 100 W | I,M | 10 |
| 2. Land Stations | I | 30 |
| 3. Mobile Stations | I | 30 |
| 4. Radionavigation Stations | | |
| 4.1 Radar | F | 800 |
| 4.2 Other than above | I | 800 |
| 5. Radiolocation Stations | | |
| 5.1 Radar | F | 800 |
| 5.2 Other than above | I | 800 |
| 6. Earth Stations | N | 20 |
| 7. Space Stations | N | 20 |
| **BAND: 4000 MHz to 10.5 GHz** | | |
| 1. Fixed Stations | | |
| 1.1 100 W or less | I.M | 50 |
| 1.2 Above 100 W | I,M | 10 |
| 2. Land Stations | I | 50 |
| 3. Mobile Stations | I | 50 |
| 4. Radionavigation Stations | | |
| 4.1 Radar | F | 1250 (z) |
| 4.2 Other than above | I | 1250 |
| 5. Radiolocation Stations | | |
| 5.1 Radar | F | 1250 (z) |
| 5.2 Other than above | I | 1250 |
| 6. Earth Stations | N | 20 |
| 7. Space Stations | N | 20 |
| **BAND: 10.5 to 30 GHz** | | |
| 1. Fixed Stations | | |
| 1.1 Band 21.2-23.6 GHz (See also Section 5.2.3) | L | 300 |
| 1.2 Other than above | I,M | 50 |
| 2. Land Stations | I | 100 |

| Frequency Bands and Station Type | Levels of Unwanted Emissions | Frequency Tolerance |
|---|---|---|
| 3. Mobile Stations | I | 100 |
| 4. Radionavigation Stations | | |
| 4.1 Radar | F | 2500 |
| 4.2 Other than above | I | 2500 |
| 5. Radiolocation Stations | | |
| 5.1 Radar | F | 2500 |
| 5.2 Other than above | I | 2500 |
| 6. Earth Stations | N | 50 |
| 7. Space Stations | N | 50 |
| 8. Broadcasting Stations | K | 100 |
| **BAND: 30 to 40 GHz** | | |
| 1. Fixed Stations | I | 75 |
| 2. Land Stations | I | 150 |
| 3. Mobile Stations | I | 150 |
| 4. Radionavigation Stations | | |
| 4.1 Radar | F | 5000 |
| 4.2 Other than above | I | 5000 |
| 5. Radiolocation Stations | | |
| 5.1 Radar | F | 5000 |
| 5.2 Other than above | I | 5000 |
| 6. Earth Stations | N | 75 |
| 7. Space Stations | N | 75 |
| 8. Broadcasting Stations | K | 100 |
| **BAND: Above 40 GHz** | | |
| 1. Fixed Stations | I | 75 |
| 2. Land Stations | I | 150 |
| 3. Mobile Stations | I | 150 |
| 4. Radionavigation Stations | I | 5000 |
| 5. Radiolocation Stations | I | 5000 |
| 6. Earth Stations | N | 75 |
| 7. Space Stations | N | 75 |

## 5.1.1 Frequency Tolerances and Unwanted Emissions

The letters A thru K in Section 5.1.3 refer to the levels of unwanted emissions.

Units for frequency tolerance are (±) parts per million (ppm) unless otherwise stated.

The power shown for the various categories of stations is the peak envelope power for singlesideband transmitters and the mean power for all other transmitters, unless otherwise indicated. (RR)

## 5.1.2 Notes For Frequency Tolerance

(a) If the emergency transmitter is used as the reserve transmitter for the main transmitter, the tolerance for ship station transmitters applies.

(b) In the area covered by the North American Regional Broadcasting Agreement (NARBA), the tolerance of 20 Hz may continue to be applied.

(c) 20 Hz is applicable to other than Aeronautical Mobile (R) frequencies.

(d) Travelers Information Stations (TIS) have a tolerance of 100 Hz.

(e) The indicated tolerance applies to new equipment after 1/1/87. A tolerance of 50 Hz applies to other equipment.

(f) For A1A emissions the tolerance is 50 ppm.

(g) The indicated tolerance applies to new equipment after 1/1/87. A tolerance of 50 ppm applies to other equipment.

(h) The indicated tolerance applies to new equipment after 1/1/87. A tolerance of 200 ppm applies to other equipment.

(i) The indicated tolerance applies to new equipment after 1/1/87. A tolerance of 300 ppm applies to other equipment.

(j) The tolerance for aeronautical stations in the Aeronautical Mobile (R) service is 10 Hz.

(k) The indicated tolerance applies to new equipment after 1/1/87. A tolerance of 30 ppm applies to other equipment.

(l) For A1A emissions the tolerance is 10 ppm.

(m) For ship station transmitters in the band 26.175-27.5 MHz, on board small craft, with a carrier power not exceeding 5W operating in or near coastal waters and utilizing A3E or F3E and G3E emissions, the frequency tolerance is 40 ppm.

(n) 50 ppm applies to wildlife telemetry with mean power output less than 0.5W.

(o) The indicated tolerance applies to new equipment after 1/1/87. A tolerance of 1000 Hz applies to other equipment.

(p) In the case of television stations of:

(1) 50W (vision peak envelope power) or less in the band 29.7-100 MHz;

(2) 100W (vision peak envelope power) or less in the band 100-965 MHz;

and which receive their input from other television stations or which serve small isolated communities, it may not, for operational reasons, be possible to maintain this tolerance. For such stations, this tolerance is 1000 Hz.

(q) See Part 5.6.

(r) This tolerance is applicable to all transmitters, including survival craft stations, after Jan 1, 1983.

(s) Except for the RR Appendix 18 Maritime Mobile frequencies, where the tolerance is 20 ppm except for transmitters put in service after January 1, 1973, a tolerance of 10 ppm shall apply, and this tolerance shall be applicable to all transmitters after January 1, 1983.

(t) Outside band 156-174 MHz, for transmitters used by on-board communications stations, a tolerance of 5 ppm shall apply.

(u) For transmitters used by on-board communications stations, a tolerance of 5 ppm applies.

(v) The indicated tolerance applies to new equipment after 1/1/87. A tolerance of 20 ppm applies to other equipment.

(w) The indicated tolerance applies to new equipment after 1/1/87. A tolerance of 400 ppm applies to other equipment.

(x) For transmitters for system M(NTSC) the tolerance is 1000 Hz. However, for low power transmitters using this system note (p) applies.

(y) The indicated tolerance applies to new equipment after 1/1/87. A tolerance of 800 ppm applies to other equipment.

(z) For 10-10.5 GHz, the indicated tolerance applies to new equipment after 1/1/87. A tolerance of 2500 ppm applies to other equipment.

(aa) The indicated tolerance applies to new equipment after 1/1/92. A tolerance of 15 Hz applies to other equipment.

(bb) The indicated tolerance applies to new equipment after 1/1/92. A tolerance of 40 Hz applies to other equipment.

(cc) The indicated tolerance applies to new equipment after 1/1/92. A tolerance of 30 applies to other equipment.

(dd) The indicated tolerance applies to new equipment after 1/1/92. A tolerance of 20 applies to other equipment.

(ee) The indicated tolerance applies to new equipment after 1/1/92. A tolerance of 10 applies to other equipment.

### 5.1.3 Levels of Unwanted Emissions

For purposes of this Manual, the term “authorized bandwidth”' is defined as the necessary bandwidth (bandwidth required for the transmission and reception of intelligence) and does not include allowance for transmitter drift or doppler shift. See, in addition, Chapter 6 for the definitions of special terms including

authorized bandwidth and mean power.

A. The mean power of any unwanted emissions supplied to the antenna transmission line, as compared with the mean power of the fundamental, shall be in accordance with the following:

1. On any frequency removed from the assigned frequency by more than 100 percent, up to and including 150 percent of the authorized bandwidth, at least 25 decibels attenuation;

2. On any frequency removed from the assigned frequency by more than 150 percent, up to and including 300 percent of the authorized bandwidth, at least 35 decibels attenuation; and

3. On any frequency removed from the assigned frequency by more than 300 percent of the authorized bandwidth, for transmitters with mean power of 5 kilowatts or greater, at least 80 decibels attenuation; and for transmitters with mean power less than 5 kilowatts, at least 43 plus 10 $\log_{10}$ (mean power of the fundamental in watts) decibels attenuation (i.e., 50 microwatts absolute level), except that

a. For transmitters of mean power of 50 kilowatts or greater and which operate over a frequency range approaching an octave or more, a minimum attenuation of 60 decibels shall be provided and every effort should be made to attain at least 80 decibels attenuation.

b. For hand-portable equipment of mean power less that 5 watts, the attenuation shall be at least 30 decibels, but every effort should be made to attain 43 plus 10 $\log_{10}$ (mean power of the fundamental in watts) decibels attenuation (i.e., 50 microwatts absolute level).

c. For mobile transmitters, any unwanted emissions shall be at least 40 decibels below the fundamental without exceeding the value of 200 milliwatts, but every effort should be made to attain 43 plus 10 $\log_{10}$ (mean power of the fundamental in watts) decibels attenuation (i.e., 50 microwatts absolute level).

d. When A1A, F1B, or similar types of narrowband emissions are generated in an SSB transmitter, the suppressed carrier may fall more than 300 percent of the authorized bandwidth from the assigned frequency. Under these conditions, the suppressed carrier shall be reduced as much as practicable and shall be at least 50 decibels below the power of the fundamental emission.

B. Unwanted emission standards for fixed and mobile SSB/ISB stations in the band 2-30 MHz are contained in Section 5.4.1.

C. Combined with B above.

D. The mean power of any emission supplied to the antenna transmission line, as compared with the mean power of the fundamental, shall be in accordance with the following:

1. On any frequency removed from the assigned frequency by more than 75 percent, up to and including 150 percent, of the authorized bandwidth, at least 25 decibels attenuation;

2. On any frequency removed from the assigned frequency by more than 150 percent, up to and including 300 percent, of the authorized bandwidth, at least 35 decibels attenuation; and

3. On any frequency removed from the assigned frequency by more than 300 percent of the authorized bandwidth:

a. For transmitters with mean power of 5 kilowatts or greater, attenuation shall be at least 80 decibels.

b. For transmitters with mean power less than 5 kilowatts, spurious output shall not exceed 50 microwatts except for frequency modulated maritime mobile radiotelephone equipment above 30 MHz as follows:

(1) The mean power of modulation products falling in any other international maritime mobile channel shall not exceed 10 microwatts for mean transmitter power 20 watts or less.

(2) The mean power of any other unwanted emission on any discrete frequency within the international maritime mobile band shall not exceed 2.5 microwatts for transmitters with mean power of 20 watts or less.

(3) For maritime mobile transmitters

of mean power above 20 watts, these 2.5 and 10 microwatt limits may be increased in proportion to the increase of the mean power of the transmitters above this 20 watts.

E. Unwanted emission standards for FM stations are contained in the following parts:

| Frequency (MHz) | Part of Manual |
|---|---|
| 29.89-50.00 | 5.6 |
| 150.8-162.0125 | 5.5 |
| 162.0125-174 | 5.6 |
| | 5.7 |
| 406.1-420 | 5.6 |

F. Unwanted emission standards for radionavigation radars and radiolocation radars are found in Part 5.3.

G. For systems with mean power above 25 watts, the unwanted emissions component attenuation shall be at least 60 dB and the absolute mean power level shall not exceed 20 milliwatts.

H. For systems with mean power 25 watts or less, the unwanted emissions component attenuation shall be at least 40 dB and the absolute mean power level shall not exceed 25 microwatts.

I. The mean power of any emission supplied to the antenna transmission line, as compared with the mean power of the fundamental, shall be in accordance with the following (above 40 GHz these are design objectives pending further experience at these orders of frequency):

1. On any frequency removed from the assigned frequency by more than 75 percent, up to and including 150 percent of the authorized bandwidth, at least 25 decibels attenuation;

2. On any frequency removed from the assigned frequency by more than 150 percent, up to and including 300 percent of the authorized bandwidth, at least 35 decibels attenuation; and

3. On any frequency removed from the assigned frequency by more than 300 percent of the authorized bandwidth, for transmitters with mean power of 5 kilowatts or greater, at least 80 decibels attenuation; and for transmitters with mean power less than 5 kilowatts, at least 43 plus 10 $\log_{10}$ (mean power of the fundamental in watts) decibels attenuation (i.e., 50 microwatts absolute level).

J. Unwanted emission standards for telemetering stations, excluding those for space radiocommunication, in the bands 1435-1535, 2200-2290 and 2310-2390 MHz are contained in Part 5.8.

K. Development of unwanted emission tolerances is pending.

L. When using transmissions other than those employing digital modulation techniques: the mean power of any emission supplied to the antenna transmission line, as compared with the mean power of the fundamental, shall be in accordance with the following (above 40 GHz these are design objectives pending further experience at these orders of frequency):

1. On any frequency removed from the assigned frequency by more than 50 percent, up to and including 100 percent of the authorized bandwidth, at least 25 decibels attenuation;

2. On any frequency removed from the assigned frequency by more than 100 percent, up to and including 250 percent of the authorized bandwidth, at least 35 decibels attenuation; and

3. On any frequency removed from the assigned frequency by more than 250 percent of the authorized bandwidth, at least 43 plus 10 $\log_{10}$ (mean output power in watts) decibels or 80 decibels, whichever is the lesser attenuation.

M. Standards for unwanted emissions for fixed services in the 406.1-420 MHz band, the 932-935/941-944 MHz bands, and in the 1710 MHz-15.35 GHz frequency range are contained in Section 5.4.2 and Part 5.6.

N. Standards for unwanted emissions for space and earth stations are contained in Part 5.7.

O. Unwanted emission standards for Narrowband fixed and Mobile/Land Mobile stations in the 162-174 MHz band are contained in Section 5.6.2.

## 5.2 SPECIAL PROVISIONS

### 5.2.1 Low Power Channels and Splinter Channels (162-174 MHz and 406-420 MHz Bands)

The following standard is for the use of low power channels identified in Section 4.3.8 and splinter channels identified in Section 4.3.10.

Transmitter Standards:

1. Frequency tolerance is expressed in parts per million (ppm).

± 2 ppm for equipment with greater than 10 watts carrier output power.

± 5 ppm for equipment with 10 watts or less carrier output power.

2. Emission--For FM or PM emission the maximum frequency deviation plus the highest audio tone shall not exceed 0.5 times the authorized bandwidth (authorized bandwidth is equal to 2D + 2M).

3. Unwanted emission levels at the equipment antenna terminals on any frequency removed from the center of the authorized bandwidth (BW) by a displacement frequency ($f_d$ in kHz) shall be attenuated below the mean power (pY) of the unmodulated carrier output as specified by the following:

| $f_d$ in kHz | Attenuation in dB |
|---|---|
| $50\%BW < f_d \leq 100\%BW$ | 25 |
| $100\%BW < f_d \leq 250\%BW$ | 35 |
| $f_d > 250\%BW$ | 43 dB + 10 log (pY) |

4. Power output--The maximum mean power of the unmodulated carrier output for operations on splinter channels in the 406-420 MHz band shall be limited to 30 watts.

5. Equipment designated for low power channels in the 162-174 MHz band as shown in Section 4.3.8 shall comply with the standards for unwanted emissions and frequency tolerances contained in Section 5.6.2.

### 5.2.2 Distress and Safety Communications

1. Global Maritime Distress and Safety System (GMDSS):

Stations in the maritime and other radio services employing frequencies and techniques used in the GMDSS shall comply with the relevant CCIR recommendations with respect to the technical characteristics of:

a. Digital selective calling (DSC) distress call formats (RR N3112.3 and N3277);

b. DSC on VHF channel 70 (156.525 MHz):

1. Capability of sensing the presence of a signal on channel 70, and

2. Automatic prevention of transmitting a DSC call on channel 70, except for a distress and safety call by DSC, when the channel is occupied by calls (Appendix 19);

c. Other aspects of DSC equipment (RR 4681);

d. Narrowband direct printing (NBDP) message formats (RR 4873) and error correction for distress, urgency, and safety messages (RR N3146, N3212, and N3232, respectively);

e. Transmissions from satellite emergency position-indicating radio beacons (EPIRBs) operating in the bands 406-406.1 MHz and 1645.5-1646.5 MHz (RR 3259A and N3276);

f. Transmissions from search and rescue radar transponders operating in the band 9200-9500 MHz (RR 824A); and

g. Broadcasts on 518 (NAVTEX) and other broadcasts of maritime safety information using NBDP in the bands 4-27.5 MHz (RR N3236).

Additionally, such stations when using DSC shall conform to the calling, acknowledgement, and operating procedures for DSC contained in the Radio Regulations (Article N39) and the relevant CCIR recommendation(s).

2. 121.5/243 MHz EPIRBs:

EPIRBs operating at 121.5 MHz and/or 243 MHz shall conform to the requirements of Appendix 37A of the Radio Regulations and Annex 10 to the Convention on International Civil Aviation, to the extent that each provision is applicable.

### 5.2.3 Low Power Transmit (21.8-22.0 and 23.0-23.2 GHz Band Segments)[1]

This standard applies to the following four frequency pairs within the above two band segments:

21.825 GHz 23.025 GHz
21.875 GHz 23.075 GHz
21.925 GHz 23.125 GHz
21.975 GHz 23.175 GHz

1. Maximum effective radiated power (ERP) shall be 55 dBm.

2. The rated transmitter output power shall not exceed 0.100 watts.

3. Frequency tolerance shall be maintained to within 500 ppm of the assigned frequency.

4. Maximum beamwidth shall not exceed four degrees with a minimum front-to-back ratio of 38 dB.

5. Upon showing need, a maximum bandwidth of 50 MHz may be authorized per frequency assigned.

6. These radio systems shall have no more than five hops in tandem, except upon showing of need, but in any event the maximum tandem length shall not exceed 40 km (25 miles).

7. Interfering signals at the antenna terminals of stations authorized shall not exceed -90 dBm and -70 dBm, respectively, for co-channel and adjacent channel interfering signals.

8. Antennas employing circular polarization may used with these systems.

## 5.3 RADAR SPECTRUM ENGINEERING CRITERIA (RSEC)

### General

The wide application of radar for various functions makes large demands on the electromagnetic spectrum, and requires the application of effective frequency management measures for the equipment and systems involved. Criteria for certain equipment characteristics are specified herein to ensure an acceptable degree of electromagnetic compatibility among radar systems, and between such systems and those of other radio services sharing the frequency spectrum.

These criteria are concerned with promoting efficient use of the spectrum, and in specifying them there is no intent to require particular numerical values from the standpoint of the radar's mission. For example, characteristics such as power, sensitivity, pulse repetition rate, pulse duration, pulse rise and fall times, and the range of radio frequency emission are closely related to operational requirements. Accordingly, where limits for some of these characteristics are specified herein, the criteria have been chosen to avoid undue degradation of operational effectiveness. Moreover, the specification of these criteria is compatible with the policy of encouraging a free and unrestricted approach in further research looking toward more effective radars. Nevertheless, any proposals for new approaches and new system concepts involving radar must be reviewed from a frequency management viewpoint prior to development of new equipment.

Useful receiver techniques are available for reduction of the susceptibility of radars to low-duty-cycle pulse interference. The applicability of such devices as video integrators, correlators, PRF and pulse width discriminators varies with factors such as cost, availability, and their adaptability to specific equipments and environmental situations. While the mandatory incorporation of such devices is not specified herein, their application is recommended for low-duty-cycle radars intended for operation in congested frequency bands and geographic areas.

All primary radars[2] shall be classified in one of five groups as shown in the following table and then shall come under the criteria indicated for that group.

For radars employing more than a single emitter, including phased array radars, variable PRF radars, radars whose modulation changes from

pulse to pulse, and other special types of radars for which any of the following criteria cannot be directly applied, special methods may be required in establishing appropriate criteria. Pending adoption of technical criteria for such radars, values submitted for these parameters shall be accompanied by an explanation of their derivation.

The provisions of Section 5.3.1, Criteria B, are applicable to Class 1 spacebased radar systems[3] on a case-by-case basis. The provisions of Section 5.3.1 or Section 5.3.2 (i.e. Criteria B or C as appropriate) are applicable to Class 2 spacebased radar systems[4] and active spaceborne sensors[5] on a case-by-case basis. See Section 8.2.41 for further guidance concerning spacebased radiolocation and active sensor systems.

In the special case where government radionavigation radars operate in the shared government/non-government band 9300-9500 MHz, an acceptable degree of electromagnetic compatibility is deemed to be that degree of compatibility associated with the radar equipments commercially available to the non-government community of users. The vast preponderance of the use of this band by non-government domestic and foreign ships and aircraft creates a situation where relatively inexpensive commercial equipment is available “off the shelf” and at the same time equipment improvements which might be incorporated unilaterally by small numbers of government stations would have little effect on the band as a whole. Accordingly, government radionavigation radars to be operated in this band having a rated peak power of 100 kW or less are placed in Group A with the understanding that government agencies would procure equipments that are acceptable for non-government use and that this exemption will be re-examined should the situation in this band change.

NTIA Report 84-157, Measurement Procedures for the Radar Spectrum Engineering Criteria, August 1984, presents one or more test procedure(s) for each of the equipment parameters covered by the RSEC that will yield adequate measured data for checking against the RSEC. These test procedures are not meant to replace any existing agency radar measurement procedures. NTIA Report 84-157 is available for purchase from the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161. (When ordering refer to NTIS Accession No. PB-85-119022.)

**Figure 1. Determination of t and $t_r$**

## Applicability of RSEC[6,7]

| Radar Description | Applicable Criteria |
|---|---|
| **Group A**<br>Non-pulsed radars of 40 watts or less rated average power; or<br>Pulsed radars of 1 kW or less rated peak power; or<br>Radars with an operating frequency above 40 GHz; or<br>Man-portable [6] radars; or<br>Man-transportable [7] radars; or<br>Radionavigation radars in the band 9300-9500 MHz; as described above; or<br>Expendable, non-recoverable radars on missiles | Criteria A<br>Presently exempt from any RSEC |
| **Group B**<br>Radars having a rated peak power of more than 1 kW but not more than 100 kW and operating between 2900 MHz and 40 GHz | Criteria B<br>See 5.3.1 |
| **Group C**<br>All radars not included in Group A, B, D or E | Criteria C<br>See 5.3.2 |
| **Group D**<br>All fixed radars in the 2700-2900 MHz band | Criteria D<br>See 5.3.3 |
| **Group E**<br>Wind Profiler Radar (WPR) operating on 449 MHz | Criteria E<br>See 5.3.4 |

## Waivers

Waiver of the requirements herein may be requested when supported by reasonable justification. When technical and engineering data are supplied in support of a request for waiver or in evaluating the performance of equipment, an explanation of the non-conforming parameters and measurement methods employed shall be furnished. Manufacturer's data may be used where deemed appropriate and adequate.

## Symbols Used

B = emission bandwidth, in MHz.

$B_c$ = bandwidth of the frequency deviation. (The total frequency shift during the pulse duration) in MHz.

$B_d$ = bandwidth of the frequency deviation (peak difference between instantaneous frequency of the modulated wave and the carrier frequency)- -(FM/CW radar systems).

$B_s$ = maximum range in MHz over which the carrier frequency will be shifted for a frequency hopping radar.

d = pulse compression ratio = emitted pulse duration/compressed pulsed duration (at 50% amplitude points).

$F_o$ = operating frequency in MHz. For non-FM pulse radars the peak of the power spectrum; for FM pulse radars the average of the lowest and highest carrier frequencies during the pulse.

N = total number of chips (subpulses) contained in the pulse. (N = 1 for non-FM and FM pulse radars.)

PG = processing gain (dB).

$P_p$ = peak power (dBm).

PRR = pulse repetition rate in pulses per second.

$P_t$ = maximum spectral power density -dBm/kHz.

t = emitted pulse duration in µ sec. at 50% amplitude (voltage) points. For coded pulses the pulse duration is the interval between 50% amplitude points of one chip (sub-pulse). The 100% amplitude is the nominal flat top level of the pulse (see Fig. 1).

$t_r$ = emitted pulse rise time in µ sec. from the 10% to the 90% amplitude points on the leading edge. See Fig. 1. For coded pulses it is the rise time of a sub-pulse; if the sub-pulse rise time is not discernible, assume that it is 40% of the time to switch from one phase or sub-pulse to the next.

$t_f$ = emitted pulse fall time in µ sec from the 90% to the 10% amplitude points on trailing edge. See Fig. 1 and endnote 9.

## 5.3.1 Criteria B

### 1. Effective Dates

Technical criteria for new radars shall become effective 1 October 1977 except as noted herein. (New radars are those for which development and subsequent procurement contracts are let after 1 October 1977.)

### 2. Applicability

These criteria are applicable to radars of Group B, “Radars having a rated peak power of more than 1 kW but not more than 100 kW and operating between 2900 MHz and 40 GHz.”

### 3. Radar Emission Bandwidth

Radars for which development and subsequent procurement contracts are let after 1 October 1977 but before 1 October 1980, shall meet the criteria in Column A below. Radars for which development and subsequent procurement contracts are let after 1 October 1980 shall meet the criteria in Column B below.

All radars procured after 1 October 1986 shall be in compliance with Column B below.

All radars procured subsequent to 1 January 1978 and prior to 1 October 1986 shall be brought into compliance with Column B by 1 October 1991.

All radars procured prior to 1 January 1978 should be brought into compliance with B when undergoing major overhaul.

The emission bandwidth for radars at the antenna input shall not exceed the following limits:

*NOTE: There is also the "necessary bandwidth" parameter that is defined for radars. For the method of calculation, see Annex J.*

**3.1 For Non-FM pulse radars** (including spread spectrum or coded pulse radars):[9]

**Column A**

$$B(-40dB) = \frac{10}{\sqrt{t_r t}} \quad or \quad \frac{64}{t}$$

whichever is less

**Column B**

$$B(-40dB) = \frac{7.6}{\sqrt{t_r t}} \quad or \quad \frac{64}{t}$$

whichever is less

**3.2 For FM-pulse radars** (intentional FM):[9]

**Column A**

$$B(-40dB) = \frac{10}{\sqrt{t_r t}} + 2\left(B_c + \frac{0.0075}{t_r}\right)$$

**Column B**

$$B(-40dB) = \frac{7.6}{\sqrt{t_r t}} + 2\left(B_c + \frac{0.065}{t_r}\right)$$

For FM-pulse radars with pulse rise time, $t_r$, of less than 0.1 microsecond, an operational justification for the short rise time shall be provided.

**3.3 For FM pulse radars** (intentional FM) with frequency hopping:[8,9]

**Column A**

$$B(-40dB) = \frac{10}{\sqrt{t_r t}} + 2\left(B_c + \frac{0.0075}{t_r}\right) + B_s$$

**Column B**

$$B(-40dB) = \frac{7.6}{\sqrt{t_r t}} + 2\left(B_c + \frac{0.065}{t_r}\right) + B_s$$

For FM pulse radars (intentional FM) with frequency hopping, but with pulse rise time, $t_r$, of less than 0.1 microsecond an operational justification for the short rise time shall be provided.

**3.4 For frequency hopping radars using nonFM pulses** (including spread spectrum or coded pulses):[8,9]

**Column A**

$$B(-40dB) = \frac{10}{\sqrt{t_r t}} + B_s$$

**Column B**

$$B(-40dB) = \frac{7.6}{\sqrt{t_r t}} + B_s$$

For this category of radars, an operational justification shall be provided if the pulse rise time, $t_r$, or fall time, $_f t$, is less than 0.01 microseconds.

**3.5 For CW radars:**

**Columns A and B**

$$B(-40dB) = 0.0003F_o$$

**3.6 For FM/CW radars:**

**Columns A and B**

$$B(-40dB) = 0.0003F_o + 2B_d$$

**4. Emission Levels**

**4.1 With the exception of CW and FM/CW radars,** the radar emission level at the antenna input shall be no greater than the values obtainable from the curve in Figure 2. At the frequency ± B(−40dB)/2 displaced from $F_o$, the level shall be at least 40 dB below the maximum value. At and beyond the frequencies ± B(−XdB)/2 from $F_o$, the level shall be at least the dB value below the maximum spectral power density given by:

$$X(dB) = 60dB, \quad or \quad X(dB) = P_t + 30$$

whichever is the larger value

Between the −40dB and −XdB frequencies the level shall be below the 20dB per decade (S=20) roll-off lines in Figure 2.

*NOTE:* $P_t$ *may be measured or may for the purpose of these criteria be calculated from the following:*

$$P_t = P_p + 20\log(Nt) + 10\log(PRR) - PG - 90$$

where PG = 0, for non-FM, non-encoded pulse radars
10log(d), for FM pulse radars
10log(N), for coded pulse radars

**4.2 For CW and FM/CW radars,** the levels of all emissions at the antenna input shall be no greater than the values obtainable from the curve in Figure 2. At the frequencies ± B(−40 dB)/2 displaced from $F_o$, the level shall be at least 40 dB below the maximum value. At and beyond the frequencies ± B(X dB)/2 from $F_o$, the level shall be at least 60 dB below the maximum level of the signal contained within B(−40 dB). All levels are specified for a 1.0 kHz measurement bandwidth. Between the −40 dB and −X dB frequencies, the level shall be below the 20 dB per decade (S=20) rolloff lines in Figure 2.

**5. Antenna Pattern**

No requirement is specified at present.

**6. Frequency tolerance**

Radar transmitters shall meet a frequency tolerance no larger than those noted in the following table:

| **Frequency Range** (MHz) | **Tolerance** (Parts/Million) |
|---|---|
| 2900-4000 | 800 |
| 4000-10,500 | 1250 |
| 10,500-30,000 | 2500 |
| 30,000-40,000 | 5000 |

**7. Radar Tunability**

Each radar shall be tunable in an essentially continuous manner either over the allocated bands for which it is designed to operate, or over a band which is 10% of the midband frequency. Crystal controlled radars conform to this requirement if operation at essentially any frequency across the band can be achieved with a crystal change.

**8. Radar Receivers**

The overall receiver selectivity characteristics shall be commensurate with or narrower than the transmitter bandwidth, as portrayed in Figure 2. Rejection of spurious responses, other than image responses, shall be 50 dB or better except where broadband front ends are required operationally. Receivers shall not exhibit any local oscillator radiation greater than −40 dBm at the receiver input terminals. The frequency stability shall be commensurate with, or better than, that of the associated transmitter.

**9. Measurement Capability**

In order to coordinate radar operations in the field, an accurate measurement of the operating frequency is necessary. An accuracy of ± 1 part of $10^6$ is desirable, although, for most radars ± 100 parts in $10^6$ is adequate. Of comparable importance is the capability to measure pulse rise time and spectrum occupancy. Accordingly, each Government agency shall have access to the instrumentation necessary to make a frequency measurement to at least ± 100 parts in $10^6$ and suitable oscilloscopes and spectrum analyzers to measure time and frequency parameters necessary to determine conformance with these criteria. For fast rise time devices, such as magnetrons, oscilloscopes with bandwidths of at least 50 MHz should be used.

**Figure 2. Radar Emission Bandwidth and Emission Levels**

**NOTE: The roll-off slope, S, from the -40 dB to -X dB points is at 20 dB per decade for Criteria B and C, and 40 to 80 dB per decade for Criteria D. The maximum emission spectrum level between the -40 dB and -X dB points for S dB per decade slope is described by the formula:**

$$Suppression\ (dB) = -S * \log \left| \frac{F - F_o}{\frac{1}{2}B(-40dB)} \right| - 40$$

$$Where:\ \frac{1}{2}B(-40dB) \le \left| F - F_o \right| \le \frac{1}{2}B(-XdB)$$

$$and:\ B(-XdB) = (10^a)\ B(-40dB)$$

$$a = \frac{X-40}{S}$$

### 5.3.2 Criteria C

**1. Effective Dates**

Technical criteria for new radars shall become effective 1 October 1977 except as noted herein. (New radars are those for which development and subsequent procurement contracts are let after 1 October 1977.)

**2. Applicability**

These criteria are applicable to radars of Group C, "all radars below 40 GHz not included in Group A, B or D".

**3. Radar Emission Bandwidth**

Radars for which development and subsequent procurement contracts are let after 1 October 1977, but before 1 October 1980, shall meet the criteria in Column A below. Radars for which development and subsequent procurement contracts are let after 1 October 1980 shall meet the criteria in Column B below.

All radars procured after 1 October 1986 shall be in compliance with Column B below.

All radars procured subsequent to 1 January 1978 and prior to 1 October 1986 shall be brought into compliance with Column B by 1 October 1991.

All radars procured prior to 1 January 1978 should be brought into compliance with B when undergoing major overhaul.

The emission bandwidth for radars at the antenna input shall not exceed the following limits:

*NOTE: There is also the "necessary bandwidth" parameter that is defined for radars. For the method of calculation, see Annex J.*

**3.1 For non-FM pulse radars** (including spread spectrum or coded pulse radars):[9]

**Column A**

$$B(-40dB) = \frac{7.6}{\sqrt{t_r t}} \quad or \quad \frac{64}{t}$$

whichever is less

**Column B**

$$B(-40dB) = \frac{6.2}{\sqrt{t_r t}} \quad or \quad \frac{64}{t}$$

whichever is less

**3.2 For FM-pulse radars** (intentional FM):[9]

**Column A**

$$B(-40dB) = \frac{7.6}{\sqrt{t_r t}} + 2\left(B_c + \frac{0.065}{t_r}\right)$$

**Column B**

$$B(-40dB) = \frac{6.2}{\sqrt{t_r t}} + 2\left(B_c + \frac{0.105}{t_r}\right)$$

For FM pulse radars with pulse rise time, $t_r$, or fall time, $t_f$, of less than 0.1 microsecond, an operational justification for the short rise time shall be provided.

**3.3 For FM pulse radars** (intentional FM) with frequency hopping:[9, 10]

**Column A**

$$B(-40dB) = \frac{7.6}{\sqrt{t_r t}} + 2\left(B_c + \frac{0.065}{t_r}\right) + B_s$$

**Column B**

$$B(-40dB) = \frac{6.2}{\sqrt{t_r t}} + 2\left(B_c + \frac{0.105}{t_r}\right) + B_s$$

For FM pulse radars (intentional FM) with frequency hopping, but with pulse rise time, $t_r$, of less than 0.1 microsecond, an operational

justification for the short rise time shall be provided.

**3.4 For frequency hopping radars using nonFM pulses** (including spread spectrum or coded pulses):[9, 10]

**Column A**

$$B(-40dB) = \frac{7.6}{\sqrt{t_r t}} + B_s$$

**Column B**

$$B(-40dB) = \frac{6.2}{\sqrt{t_r t}} + B_s$$

For this category of radars, an operational justification shall be provided if the pulse rise time, $t_r$, is less than 0.01 microsecond.

**3.5 For CW radars:**

**Columns A and B**

$$B(-40dB) = 0.0003F_o$$

**3.6 For FM/CW radars:**

**Columns A and B**

$$B(-40dB) = 0.0003F_o + 2B_d$$

**4. Emission Levels**

**4.1 With the exception of CW and FM/CW radars,** the radar emission levels at the antenna input shall be no greater than the values obtainable from the curve in Figure 2. At the frequency ± B(−40dB)/2 displaced from $F_o$, the level shall be at least 40 dB below the maximum value. At and beyond the frequencies ± B(−XdB/2) from $F_o$, the level shall be at least the dB value below the maximum spectral power density given by:

$$X(dB) = 60dB, \quad or \quad X(dB) = P_t + 30$$

whichever is the larger value

Between the −40dB and −XdB frequencies the level shall be below the 20dB per decade (S=20) roll-off lines in Figure 2.

*NOTE:* $P_t$ *may be measured or may for the purpose of these criteria be calculated from the following:*

$$P_t = P_p + 20\log(Nt) + 10\log(PRR) - PG - 90$$

where PG = 0, for non-FM, non-encoded pulse radars
10log(d), for FM pulse radars
10log(N), for coded pulse radars

**4.2 For CW and FM/CW radars,** the levels of all emissions at the antenna input shall be no greater than the values obtainable from the curve in Figure 2. At the frequencies ± B(−40 dB)/2 displaced from $F_o$, the level shall be at least 40 dB below the maximum value. At and beyond the frequencies ± B(X dB)/2 from $F_o$, the level shall be at least 60 dB below the maximum level of the signal contained within B(−40 dB). All levels are specified for a 1.0 kHz measurement bandwidth. Between the −40 dB and −X dB frequencies, the level shall be below the 20 dB per decade (S=20) rolloff lines in Figure 2.

**5. Antenna Pattern**

Since electromagnetic compatibility considerations involved phenomena which may occur at any angle, the allowable antenna patterns for many radars may be usefully described by "median gain" relative to an isotropic antenna.[11] Antennas operated by their rotation through 360° of the horizontal plane shall have a "median gain" of −10 dB or less, as measured on an antenna test range, in the principal horizontal plane. For other antennas, suppression of lobes other than the main antenna beam shall be provided to the following levels, referred to the

main beam:

first three sidelobes--17 dB;
all other lobes--26 dB.

**6. Frequency Tolerance**

Radar transmitters shall meet a frequency tolerance no larger than those noted in the following table:

| **Frequency Range** (MHz) | **Tolerance** (Parts/Millions) |
|---|---|
| Below 960 | 400 |
| 960-4,000 | 800 |
| 4,000-10,500 | 1,250 |
| 10,500-30,000 | 2,500 |
| 30,000-40,000 | 5,000 |

**7. Radar Tunability**

Each radar shall be tunable in an essentially continuous manner either over the allocated bands for which it is designed to operate, or over a band which is 10% of the midband frequency. Crystal controlled radars conform to this requirement if operation at essentially any frequency across the band can be achieved with a crystal change.

**8. Radar Receivers**

The overall receiver selectivity characteristics shall be commensurate with the transmitter bandwidth, as portrayed in Figure 2. Receivers shall be capable of switching bandwidth limits to appropriate values whenever the transmitter bandwidth is switched (pulse shape changed). Receiver image rejection shall be at least 50 dB; rejection of other spurious responses shall be at least 60 dB. Radar receivers shall not exhibit any local oscillator radiation greater than −40 dBm at the receiver input terminals. Frequency stability of receivers shall be commensurate with, or better than, that of the associated transmitters.

**9. Measurement Capability**

In order to coordinate radar operations in the field, an accurate measurement of the operating frequency is necessary. An accuracy of ± 100 parts in $10^6$ is adequate. Of comparable importance is the capability to measure pulse rise time and spectrum occupancy. Accordingly, each Government agency shall have access to the instrumentation necessary to make a frequency measurement to at least ± 100 parts in $10^6$ and suitable oscilloscopes and spectrum analyzers to measure time and frequency parameters necessary to determine conformance with these criteria. For fast rise time devices, such as magnetrons, oscilloscopes with bandwidths of at least 50 MHz should be used.

### 5.3.3 Criteria D

**1. Effective Dates**

Technical criteria for new fixed radars in the 2700-2900 MHz band shall become effective on 1 October 1982. (New radars are those for which the initial system procurement contract is let after 1 October 1982.)

**2. Applicability**

These criteria are applicable to fixed radars in the 2700-2900 MHz band. All radars subject to these criteria shall be designed and constructed to meet the basic minimum electromagnetic compatibility (EMC) requirements stated herein. In addition to the basic minimum EMC requirements, radar systems in the 2700-2900 MHz band which are intended to operate in close proximity to other equipment in the band or operate in areas specified in Annex D shall be designed and constructed to permit, without modification to the basic equipment, field incorporation of EMC enhancement provisions. These additional provisions will improve the electromagnetic compatibility of the radar thus improving the accommodation of the radar system in the band. These provisions are stated in Section 5.3.3, paragraph 9.

**3. Radar Emission Bandwidth**

The emission bandwidth for radars at the antenna input shall not exceed the following limits:

**3.1 For non-FM pulse radars** (including spread spectrum or coded pulse radars):[9]

$$B(-40dB) = \frac{6.2}{\sqrt{t_r t}}$$

For non-FM pulse radars, a pulse rise time, $t_r$, or fall time, tf,of less than 0.1t shall be justified:

**3.2 For FM-pulse radars** (intentional FM):[9]

$$B(-40dB) = \frac{6.2}{\sqrt{t_r t}} + 2(B_c + \frac{0.105}{t_r})$$

For FM pulse radars with pulse rise time, $t_r$, of less than 0.1 microsecond, a justification for the short rise time shall be provided.

**3.3 For FM pulse radars** (intentional FM) with frequency hopping:[9, 12]

$$B(-40dB) = \frac{6.2}{\sqrt{t_r t}} + 2(B_c + \frac{0.105}{t_r}) + B_s$$

For FM pulse radars (intentional FM) with frequency hopping, but with pulse rise time, $t_r$, of less than 0.1 microsecond, an operational justification for the short rise time shall be provided.

**3.4 For frequency hopping radars using non-FM pulses** (including spread spectrum coded pulses):[9,11]

$$B(-40dB) = \frac{6.2}{\sqrt{t_r t}} + B_s$$

For this category of radars, an operational justification shall be provided if the pulse rise time, $t_r$, is less than 0.01 microsecond.

**3.5 For CW radars:**

$$B(-40dB) = 0.0003F_o$$

**3.6 For FM/CW radars:**

$$B(-40dB) = 0.0003F_o + 2B_d$$

**4. Emission Levels**

**4.1 With the exception of CW and FM/CW radars,** the radar emission levels at the antenna input shall be no greater than the values obtainable from the curve in Figure 2. At the frequency ± B(−40 dB)/2 displaced from $F_o$ the level shall be at least 40 dB below the maximum value. Beyond the frequencies ± B(−40 dB)/2 from $F_o$, the emission level (s), with the exception of harmonic frequencies, shall be below the 40 dB per decade (S=40) roll-off lines of Figure 2 down to a −X dB level that is 80 dB below the maximum spectral power density. All harmonic frequencies shall be at a level that is at least 60 dB below the maximum spectral power density.

**4.2 For CW and FM/CW radars,** the levels of all emissions at the antenna input shall be no greater than the values obtainable from the curve in Figure 2. At the frequencies ± B(−40 dB)/2displaced from $F_o$, the level shall be at least 40 dB below the maximum value. At and beyond the frequencies B(X dB)/2 from $F_o$, the level shall be at least 80 dB below the maximum level of the signal contained with B(−40 dB). All levels are specified for a 1.0 kHz measurement bandwidth. Between the −40 dB and −X dB frequencies, the level shall be below the 40 dB per decade (S=40) rolloff lines in Figure 2.

**5. Antenna Pattern**

Since electromagnetic compatibility considerations involved phenomena which may occur at any angle, the allowable antenna patterns for many radars may be usefully described by "median gain" relative to an isotropic antenna.[13] Antennas operated by their rotation through 360 degrees of the horizontal plane shall have a "median gain" of −10 dB or less, as measured on an antenna test range, in the principal horizontal plane. For other antennas, suppression of lobes other than the main antenna beam shall be provided to the following levels, referred to the main beam:

first three sidelobes--17 dB;
all other lobes--26 dB.

**6. Frequency Tolerance**

Radar transmitters shall meet a frequency tolerance no greater than 800 parts/million.

**7. Radar Tunability**

Radar systems shall be tunable over the entire 2700-2900 MHz band.

**8. Radar Receiver**

The overall receiver selectivity characteristics shall be commensurate with the transmitter bandwidth, as portrayed in Figure 2. Receivers shall be capable of switching bandwidth limits to appropriate values whenever the transmitter bandwidth is switched (pulse shape changed). Receiver image rejection shall be at least 50 dB; rejection of other spurious responses shall be at least 60 dB. Radar receivers shall not exhibit any local oscillator radiation greater than −40 dBm at the antenna input terminals. Frequency stability of receivers shall be commensurate with, or better than, that of the associated transmitters.

**9. Additional EMC Provisions**

To improve the accommodation of radar systems in the 2700-2900 MHz band which operate in close proximity to other equipment in the band or operate in areas specified in Annex D, the radar shall be designed and constructed to permit, without modification to the basic equipment, field incorporation of system EMC provisions. These provisions include the requirement to meet specifications in accordance with paragraphs a. and b. below and the recommendation to meet guidelines in accordance with paragraph c. below.

a. Emission Levels

The radar emission levels at the antenna input shall be no greater than the values obtainable from the curves in Figure 2. At the frequency ± B(−40 dB)/2 displaced from $F_o$, the level shall be at least 40 dB below the maximum value. Beyond the frequencies ± B(−40 dB)/2 from $F_o$, the equipment shall have the capability to achieve up to 80 dB per decade (S= 80) roll-off lines of Figure 2. The emission levels, with the exception of harmonic frequencies, shall be below the appropriate dB per decade roll-off lines of Figure 2 down to a −X dB level that is 80 dB below the maximum spectral power density. All harmonic frequencies shall be at a level that is at least 60 dB below the maximum spectral power density.

b. Radar System PRF

The radar system shall be designed to operate with an adjustable pulse repetition frequency (s), PRF (s), with a nominal difference of ± 1% (minimum). This will permit the selection of PRF's to allow certain types of receiver interference suppression circuitry to be effective.

c. Receiver Interference Suppression Circuitry

Radar systems in this band should have provisions incorporated into the system to suppress pulsed interference. The following information is intended for use as an aid in the design and development of receiver signal processing circuitry or software to suppress asynchronous pulsed interference. A description of the parametric range of the expected environmental signal characteristics at the receiver IF output is:

Peak Interference-to-Noise Ratio: ≤ 50 dB
Pulse width: 0.5 to 4.0 µsec
PRF: 100 to 2000 pps

**10. Measurement capability**

In order to coordinate radar operations in the field, an accurate measurement of the operating frequency is necessary. An accuracy of ± 100 parts in $10^6$ is adequate. Of comparable importance is the capability to measure pulse rise time and spectrum occupancy. Accordingly, each Government agency shall have access to the instrumentation necessary to make a frequency measurement to at least ± 100 parts in $10^6$ and

suitable oscilloscopes and spectrum analyzers to measure time and frequency parameters necessary to determine conformance with these criteria. For fast rise time devices, such as magnetrons, oscilloscopes with bandwidths of at least 50 MHz should be used.

### 5.3.4 Criteria E

**1. Effective Dates**

Technical criteria for new wind profiler radars (WPR) operating on 449 MHz shall become effective on 1 January 1994. (New WPRs are those for which the initial systems procurement contract is let after 1 January 1994.)

**2. Applicability**

These criteria are applicable to WPR's operating on 449 MHz.

**3. Emission Bandwidth**

The emission bandwidth for WPR's at the antenna input shall not exceed the following limits:

**3.1 For non-FM pulse radars (including coded pulse radars):**

$$B(-40dB) = \frac{6.2}{\sqrt{t_r t}} \quad or \quad \frac{64}{t}$$

whichever is less.

**3.2 For FM-pulse radars (intentional FM):**

$$B(-40dB) = \frac{6.2}{\sqrt{t_r t}} + 2\left(B_c + \frac{0.105}{t_r}\right)$$

**3.3 For wind profiler radars,** an operational justification shall be provided if the pulse rise time, $t_r$, is less than 0.01 microsecond.

**3.4 For CW radars**

$$B(-40dB) = 0.0003F_o$$

**3.5 For FM/CW radars**

$$B(-40dB) = 0.0003F_o + 2B_d$$

**4. Emission Levels**

WPR emission levels at the antenna input shall be no greater than the values obtainable from the curve in Figure 3. At the Frequencies ± B(-40 dB)/2 displaced from $F_0$, the level shall be at least 40 dB below the maximum value. At and beyond the frequencies ± B(-XdB)/2 from $F_0$, the level shall be at least the dB value below the maximum spectral power density given by:

$$X(dB) = 60dB, \quad or \quad X(dB) = P_t + 30$$

whichever is the greater attenuation

Between the -40 dB and -X dB frequencies, the level shall be below the 40 dB per decade (S=40) roll-off lines in Figure 3. All harmonic frequencies shall be at a level that is at least 60 dB below the maximum spectral power density.

NOTE: $P_t$ may be measured or may for the purpose of these criteria be calculated from the following:

$$P_t = P_p + 20\log(Nt) + 10\log(PRR) - PG - 90$$

**5. Antenna Gain Characteristics**

The center of the antenna main beam generated at any time shall be limited within a cone of half-angels that are 20 degrees from the zenith. The sidelobe levels (excluding the main beam) in all azimuths shall not exceed the following values:

| | | **Median** | **Maximum** |
|---|---|---|---|
| for | elevation angle ≥ 45 degrees | 0 dBi | 12 dBi |
| for 5< | elevation angle < 45 degrees | -5 dBi | 7 dBi |
| for | elevation angle ≤ 5 degrees | -20 dBi | -8 dBi |

**6. Frequency Tolerance**

WPR transmitters shall meet a frequency tolerance no greater that 10 parts per million.

**7. WPR Receiver**

The -3 dB receiver bandwidth should be commensurate with the authorized emission bandwidth plus twice the frequency tolerance of the transmitter as specified in paragraph 5.3.4.6. The -60 dB receiver bandwidth shall be commensurate with the -60 dB emission bandwidth. Receivers shall be capable of switching bandwidth limits to appropriate values whenever the transmitter bandwidth is switched (pulse shape changed). Receiver IF image frequency rejection shall be at least 50 dB. Rejection of other spurious responses shall be at least 60 dB. WPR receivers shall not exhibit any local oscillator radiation greater than -40 dBm at the antenna input terminals. Frequency stability of receivers shall be commensurate with, or better than, that of the associated transmitters.

**8. EMC Provision**

WPR's shall have the capacity to tolerate incoherent pulsed interference of duty cycles less than 1.5 percent such that peak interfering signal levels 30 dB greater than WPR receiver noise level at the IF output will not degrade WPR performance.

**9. Measurement Capability**

In order to coordinate radar operations in the field, an accurate measurement of the operating frequency is necessary. An accuracy of 1.0 part per million is adequate. Of comparable importance is the capability to measure pulse rise time and spectrum occupancy. Accordingly, the instrumentation necessary to make a frequency measurement shall have at least 1.0 part per million and suitable oscilloscopes and spectrum analyzers to measure time and frequency parameters necessary to determine conformance with these criteria. Measurement instruments shall have resolution bandwidths of at least 10 kHz to measure close in bandwidth limits, and otherwise 100 kHz bandwidth below 1 GHz and 1 MHz bandwidth at and above 1 GHz should be used.

**10. ERP**

The peak EIRP of any WPR operating at 449 MHz shall not exceed 110 dBm.

**Figure 3. Radar Emission Bandwidth and Emission Levels for Wind Profiler Radars at 449 MHz (Criteria E)**

**Note: The roll-off slope, S, from the -40 dB to -X dB points is at 40 dB per decade for Criteria E. The -20 dB bandwidth is limited to 2 MHz for Wind Profiler radars operating at 449 MHz. The maximum emission spectrum level between the -40 dB and -X dB points for S dB per decade slope is described by the formula:**

$$Suppression\ (dB) = -S * \log\left|\frac{F - F_o}{\frac{1}{2}B(-40dB)}\right| - 40$$

$$Where:\ \frac{1}{2}B(-40dB) \le |F - F_o| \le \frac{1}{2}B(-XdB)$$

$$and:\ B(-XdB) = (10^a)\ B(-40dB)$$

$$a = \frac{X-40}{S}$$

## 5.4 HF SSB AND ISB FOR FIXED AND MOBILE SERVICES

### 5.4.1 Single Sideband and Independent Sideband Equipments. (2-30 MHz)

This standard specifies that spectrum standards for single sideband equipment for single channel voice, direct printing telegraphy and data, in the Fixed and Mobile services between 2 and 30 MHz (Except in the bands allocated exclusively to the Aeronautical Mobile (R) service[19]. In using the spectrum standards indicated below, it should be recognized that they do not prohibit an agency from making improvements thereon.

**A. Transmitter Standards**

1. The frequency tolerance of transmitters shall be 20 Hz except for ship transmitters which are permitted a tolerance of 50 Hz.

2. For unwanted emissions for fixed and mobile services (except the land mobile service), the peak power of any emission on any frequency removed from the center of the authorized bandwidth[14] (BW) by a displacement frequency ($f_d$ in kHz) shall be attenuated below the peak envelope power (pX) of the transmitter in accordance with the following schedule:

| **$f_d$ in kHz** | **Attenuation in** dB |
|---|---|
| $50\%BW<f_d\leq 150\%BW$ | 26 |
| $150\%BW<f_d\leq 250\%BW$ | 35 |
| $f_d>250\%BW$ | 40 + 10 log(pX) or 80 whichever is the lesser attenuation. |

For the land mobile service, the peak power of any emission on any frequency removed from the center of the authorized bandwidth[7] (BW) by a displacement frequency ($f_d$ in kHz) shall be attenuated below the peak envelope power (pX) of the transmitter in accordance with the following schedule:

| **$f_d$** in kHz | **Attenuation in dB** |
|---|---|
| $1.75kHz\leq f_d<5.25kHz$ | 28 |
| $5.25kHz\leq f_d<8.75kHz$ | 38 |
| $f_d>8.75kHz$ | 43+10 log (pX) |

3. Where suppressed carrier operation is employed, transmitters shall be capable of operation with the emitted carrier power attenuated at least 40 dB below peak envelope power.

4. Where interoperability with conventional double sideband AM receivers is required, single sideband transmitters shall have the capability to transmit the carrier at a level within 6 dB of the peak envelope power.

5. The upper sideband mode shall be employed where there is need for working among international services.

**B. Receiver Standards**

1. Selectivity. The passband[15] shall be no greater than the authorized bandwidth of emission and the slope of the selectivity characteristic outside the passband shall be 100 dB/kHz.

2. Tunability. The equipment shall be capable of operation on any frequency within its tuning range. However, where a synthesizer is employed as the frequency controlling element, the receiver shall be capable of operation on any frequency which is an integral multiple of 0.1 kHz.

**C. Antenna Standards**[16]

**FIXED SERVICE**

1. Directive antennas are not required below 4 MHz. Directive antennas shall be employed above 4 MHz unless in specific cases they are shown to be impracticable.

2. Minimum forward power gain over an isotropic radiator located at the same height over the same earth as directive antenna shall be 10 dB in the range 4 to 10 MHz and 15 dB[17] in the range 10 to 30 MHz. The gain of any reference antenna used in an actual measurement must be specified relative to an isotropic antenna.

3. The antenna gain in the desired direction over that of a lobe in any other direction shall be greater than 6 dB.

**MOBILE SERVICE**

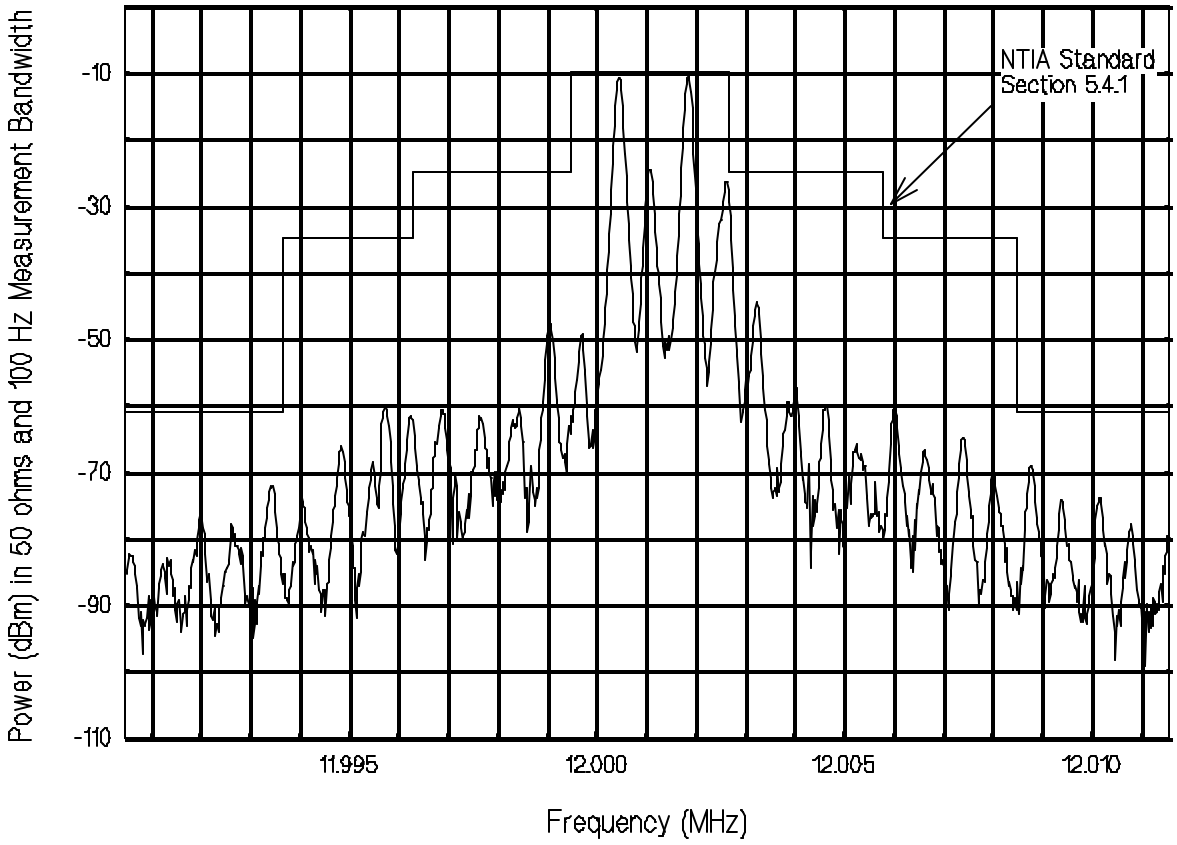
To the extent practicable, land stations shall use antennas designed so as to reduce their radiation and/or their susceptibility to interference in those directions where service is

not requeired.

**D. Measurement Method**

1. For HF Single sideband transmitters, the transmitter without a device to limit modulation or peak envelope power shall be modulated as follows: The input level of the modulation signal shall be that necessary to produce rated peak envelope power. HF single sideband transmitters in J3E, H3E, or R3E emission modes shall be modulated by two tones at frequencies on 400 Hz and 1800 Hz (for 3.0 kHz authorized bandwidth), applied simultaneously. The input levels of the tones shall be so adjusted that the two principle frequency components of the radio frequency signal produced are equal in magnitude and 3 dB below the maximum received signal level (RSL) as indicated in Figure 5.4.1. The plot of the spectrum shall have a span of 21.1 kHz or that necessary to identify intermodulation products up through the 13th and a resolution bandwidth of 100 Hz. This measurement method is also contained in Title 47 CFE Section 2.989 (d)(2).

2. Figure 5.4.1 below provides an example of HF SSB emission plotted using the measurement method described above. The figure also shows the standard superimposed on the plot to show conformance.




**RSL (dBm) vs Frequency (MHz)**

**Figure 5.4.1**

Example of measured Emission for HF SSB Transmitter Fundamental with NTIA Standard in Section 5.4.1. Modulation Tones = 400 Hz and 1800 Hz, Res. BW = 100 Hz, Span = 21.1 kHz.

### 5.4.2 Fixed Services (406.1-420 MHz Band, the 932-935/941-944 MHz Bands, and the 1710 MHz-15.35 GHz Frequency Range)

The following standard is for Federal Government Fixed Services employing: (a) multichannel equipments in the 406.1-420 MHz band, (b) point-to-point and point-to-multipoint equipments in the bands 932-935/941-944 MHz, or (c) point-to-point and transportable type equipments operating between 1710 MHz and 15.35 GHz (except for systems designed to use scatter techniques or where other specific exceptions are stated herein).

This standard became effective on August 28, 1990, for fixed operations (point-to-point and point-to-multipoint) in the bands 932-935/941-944 MHz. These bands were allocated for Government and non-Government fixed service usage on a co-primary basis on February 1, 1985. Standards for receivers operating in the bands 932-935/941-944 MHz, are not mandatory and are presented herein to provide

guidelines to promote efficient and effective use of these shared frequencies.

This standard became effective on January 1, 1987, for multichannel equipments operating in the 406.1-420 MHz band. Such equipment placed in operation or contracted for prior to January 1, 1987, may continue to operate without regard to the requirements of this standard.

This standard became effective on January 1, 1979, for fixed equipments operating in the 1710-15.35 GHz frequency range. Such equipment placed in operation or contracted for prior to January 1, 1979 may continue to operate without regard to the requirements of this standard until January 1, 1994.

**A. Transmitter Standards**

1. The frequency tolerance of transmitters shall be:

| | |
|---|---|
| 406.1-420 MHz | 2.5 ppm. |
| 932-932.5 MHz and 941-941.5 MHz | 1.5 ppm (point-to-multipoint) |
| 932.5-935 MHz and 941.5-944 MHz | 2.5 ppm (point-to-point) |
| 1.7-4.0 GHz | 30 ppm for 100W or less transmitter power. |
| | 10 ppm for transmitter power above 100W |
| 4.0-10.5 GHz | 50 ppm for 100W or less transmitter power. |
| | 10 ppm for transmitter power above 100W. |
| 10.5-15.35 GHz | 50 ppm. |

Measurement Method. A sample of the unmodulated carrier at the center frequency should be measured with equipment having an accuracy of at least five times that of the minimum to be measured.

2. Unwanted Emissions. The average power of any emission on any frequency removed from the center of the authorized bandwidth (BW) by a displacement frequency ($f_d$ in kHz) shall be attenuated below the mean output power (pY) of the transmitter in accordance with the following schedule:

(a) For transmission other than those employing digital modulation techniques:

| **$f_d$ in kHz** | **Attenuation in** dB |
|---|---|
| 50%BW<$f_d$≤100%BW | 25 |
| 100%BW<$f_d$≤250%BW | 35 |
| $f_d$>250%BW | 43 + 10log (pY) or 43 whichever is the greater attenuation |

Attenuation greater than 80 dB is not required.

(b) For transmissions employing digital-modulation techniques:[18]

In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 50 percent, up to and including 250 percent, of the authorized bandwidth as specified by the following equation but at least 50 decibels:

$A = 35 + 0.8(\%-50)+10 \log BW$

where:

A = attenuation (in decibels) below the mean output power level, % = percent of the authorized bandwidth removed from the assigned frequency.

BW = authorized bandwidth in MHz.

Attenuation greater than 80 decibels is not required.

In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 250 percent of the authorized bandwidth: At least 43 plus 10 $\log_{10}$ (mean output power in watts) decibels, or 80 decibels, whichever is the lesser attenuation.

Measurement Method. A sample of the transmitter output at the interface point with the antenna transmission line shall be measured using a measurement system with 4 kHz resolution bandwidth. The full unmodulated carrier power output is used as the transmitter average

power output reference.

Measurement of the unwanted emissions shall be made from the lowest radio frequency generated in the equipment to the third harmonic of the carrier with the transmitter modulated as follows:

(1.) Analog--white noise generator in accordance with EIA Standard RS-252A recommended loading levels.

(2.) Digital--pseudorandom code generator with appropriate loading levels and format.

(3.) When using transmissions employing digital modulation techniques on the 900 MHz multiple address frequencies with a 12.5 kHz bandwidth, the power of any emission shall be attenuated below the unmodulated carrier power of the transmitter (P) in accordance with the following schedule:

(i) On any frequency removed from the center of the authorized bandwidth by a displacement frequency ($f_d$ in kHz) of more than 2.5 kHz up to and including 6.25 kHz: At least 53 $\log_{10}(f_d/2.5)$ decibels;

(ii) On any frequency removed from the center of the authorized bandwidth by a displacement frequency ($f_d$ in kHz) of more than 6.25 kHz up to and including 9.5 kHz: At least 103 $\log_{10}(f_d/3.9)$ decibels;

(iii) On any frequency removed from the center of the authorized bandwidth by a displacement frequency ($f_d$ in kHz) of more than 9.5 kHz up to and includeing 15 kHz: At least 157 $\log_{10}(f_d/5.3)$ decibels;

(iv) On any frequency removed from the center of the authorized bandwidth by a displacement frequency greater that 15 kHz: At least 50 plus 10 $\log_{10}$(P) or 70 decibels, whichever is the lesser attenuation.

(4) When using transmissions employing digital modulation techniques on the 900 MHz multiple address frequencies with a bandwidth greater that 12.5 kHz, the power of any emission shall be attenuated below the unmodulated carrier power of the transmitter (P) in accordance with the following schedule;

(i) On any frequency removed from the center of the authorized bandwidth by a displacement frequency ($f_d$ in kHz) of more than 5 kHz up to and including 10 kHz: At least 83 $\log_{10}$ ($f_d$/5) decibels;

(ii) On any frequency removed from the center of the authorized bandwidth by a displacement frequency ($f_d$ in kHz) of more than 10 kHz up to and including 250 percent of the authorized bandwidth: At least 116 $\log_{10}$ ($f_d$/6.1) or 50 plus 10 log (P) or 70 decibels, whichever is the lesser attenuation;

(iii) On any frequency removed from the center of the authorized bandwidth by more than 250 percent of the authorized bandwidth: At least 43 plus 10 $\log_{10}$(output power in watts) decibels or 80 decibels, whichever is the lesser attenuation.

The maximum equivalent isotropic radiated power (EIRP) shall not exceed the values specified below. However, the additional constraints of Section 8.2.34 of this manual apply.

| **Frequency Band** (MHz) | **Maximum Allowable EIRP** (dBm) |
|---|---|
| 406.1-420 | 80 |
| 932-932.5 | 47 |
| 932.5-935 | 70 |
| 941-941.5 | 60 |
| 941.5-944 | 70 |
| 1710-4990 | 80 |
| 7125-15350 | 85 |

**B. Receiver Standards**

1. For the 406.1-420 MHz band, the receiver frequency tolerances shall be maintained within ± 10 ppm. For all other systems the receiver Intermediate frequency (IF) shall be maintained at the specified center of the receiver passband within ± 2 percent of the −3 dB receiver IF bandwidth when the receiver carrier is at its assigned frequency.

Measurement Method. The Intermediate Frequency (IF) shall be measured with equipment having an accuracy of at least five times greater than the frequency tolerance to be

measured. The measurement shall be made with an unmodulated input signal on the assigned frequency coupled to the input of the receiver at a level greater than 20 dB above the receiver ambient noise.

2. The receiver unwanted signals shall be attenuated at least 60 dB relative to the receiver sensitivity at the center of the passband.

Measurement Method. Couple two signal generators to the input of the receiver and connect a spectrum analyzer to the baseband output. The unmodulated output of one signal generator (desired signal) on the assigned frequency shall be adjusted to reduce the baseband noise by 3 dB as observed on the spectrum analyzer. The unmodulated output of the second signal generator (unwanted signals) shall be adjusted to 70 dB above that of the desired signal. The output frequency of the unwanted signals shall be varied over a range of ±1 percent of the assigned frequency excluding frequencies within the receiver 60 dB selectivity bandwidth.

At each receiver response of the unwanted frequency, adjust the output of the unwanted signal generator for a 3 dB reduction in baseband noise. The difference, expressed in dB, in the output levels of the two signal generators is the unwanted signal attenuation.

3. Selectivity. Receiver selectivity is the degree to which a receiver is able to discriminate against the effects of undesired signals primarily outside the authorized emission bandwidth that arrive at its RF input terminals.

The −3 dB receiver bandwidth should be commensurate with the authorized emission bandwidth plus twice the frequency tolerance of the transmitter specified in Section 5.4.2 A. The −60 dB receiver bandwidth shall not exceed five times the −3 dB receiver bandwidth.

4. Conducted Undesired Emissions are those undesired signals generated in the receiver and leaving the receiver by way of the receiving transmission line.

Conducted emissions from the receiver on any frequency, as measured at the radio frequency interface point to the antenna system, shall not exceed −85 dBW. For the bands 406.1-420 MHz and 932-935/941-944 MHz, conducted emissions shall not exceed −80 dBW.

5. Noise Figure. The noise figure of a receiver is the ratio expressed in dB of (1) the output noise power to (2) the portion of noise power attributable to thermal noise in the input termination at 290 kelvins.

The receiver noise figure including pre-amplifier should be 9 dB or less for frequencies below 4400 MHz, 12 dB or less for frequencies between 4400 MHz, and 10 GHz, and 14 dB or less for higher frequencies (up to 15.35 GHz).

**C. Antenna Standards**

The following limitations do not apply to transportable antenna systems when used in tactical and training operations. Additionally, the following limitations do not apply to multipoint distribution systems (point-to-multipoint) operating in the bands 406.1-420, 932-932.5 and 941-941.5 MHz.

1. Each station shall employ directional antennas with the major lobe of radiation directed toward the receiving station with which it communicates, or toward any passive repeater that may be used.

2. Antenna Radiation Pattern. The antenna radiation pattern is the relative power gain as a function of direction for the specified polarization.

Directional antennas shall meet the performance standards indicated in Table 5.4.2. For assignments in bands shared with satellite-space services, determination on additional beamwidth limitations shall be made on a case-by-case basis if mutual interference problems are likely to be involved.

**TABLE 5.4.2**

| Frequency Band | Maximum beamwidth (3 dB point) | Minimum suppression at angle in degrees from center line of main beam (dB) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 5-10 ° | 10-15 ° | 15-20 ° | 20-30 ° | 30-100 ° | 100-140 ° | 140-180 ° |
| 406.1-420 MHz [1] | 80 ° | - | - | - | - | 10 | 10 | 10 |
| a) 932.5-935 MHz/941.5-944 MHz [2] | 14 ° | - | 6 | 11 | 14 | 17 | 20 | 24 |
| b) 932.5-935 MHz/941.5-944 MHz [2] | 20 ° | - | - | 6 | 10 | 13 | 15 | 20 |
| 1710-1850 MHz [3] | 10 ° | - | 14 | 16 | 18 | 23 | 24 | 30 |
| 1710-1850 MHz [4] | 8 ° | 5 | 18 | 20 | 20 | 25 | 28 | 36 |
| 2200-2400 MHz | 8.5 ° | 4 | 12 | 16 | 16 | 24 | 25 | 30 |
| 4.4-4.99 GHz | 4 ° | 13 | 20 | 23 | 24 | 29 | 31 | 31 |
| 7.125-8.5 GHz | 2.5 ° | 19 | 23 | 28 | 30 | 34 | 35 | 43 |
| 14.4-15.35 GHz | 1.5 ° | 21 | 26 | 31 | 35 | 37 | 41 | 48 |

1 - Any secondary lobe.
2 - Stations in this service must employ an antenna that meets the performance standard except that, in areas not subject to frequency congestion, subject to frequency coordination along the borders of the U.S., antennas meeting standards for category B may be employed. Note, however, the use of a high performance antennas may be required where interference problems can be resolved by the use of such antennas.
3 - These suppression levels could be met, e.g., by a 1.2 meter (4 foot) diameter parabolic antenna.
4 - This standard is applicable to new stations in the 1710-1850 MHz band placed in service after January 1, 1985, except for those located on the military test ranges specified in Section 7.17.1 and those limitations noted in Section 5.4.2.C. These suppression levels could be met, e.g., by a 1.83 meter (6 foot) diameter parabolic antenna.

## 5.5 MOBILE

### 5.5.1 ( Reserved )

### 5.5.2 Mobile, Maritime, FM Operation, (150.8-162.0125 MHz)

The following standard is for mobile operations in the Maritime Mobile service using FM emissions in the band from 150.8 to 162.0125 MHz with necessary bandwidth less than or equal to 16 kHz.

**A. Transmitter Standards**

The transmitted carrier frequency shall be maintained within the following tolerances:

| Transmitter pY (watts) | Station Type | Frequency Tolerance (ppm) |
|---|---|---|
| pY<3 | Coast | 100 |
| 3≤pY≤50 | Coast | 50 |
| pY<25 | Ship | 100 |

Measurement method to be used is as given in the latest revision of Electronic Industries Association (EIA) Standard RS-152, Minimum Standards for FM or equivalent.[19]

After January 21, 1997, ship station trans-

mitters, except portable ship station transmitters, must be capable of automatically reducing power to one watt or less when tuned to the frequency 156.375 MHz or 156.650 MHz. A manual override device must be provided which when held by the operator will permit full carrier power operation on these channels.

### 5.5.3 Land Mobile, Single Channel NB Operations in the 220-222 MHz Band

The 220-222 MHz band was reallocated on September 6, 1988 exclusively for shared Government and non-Government land mobile, single channel, narrowband operations with necessary bandwidth less than or equal to 4 kHz. The 2 MHz available in this band are allocated in 400 5 kHz wide-frequencies paired to create 200 narrowband channels. Of these, 10 channels are allocated exclusively for Government nationwide use and 100 channels are for shared Government and non-Government trunked operations.

This standard becomes effective on January 1, 1992 for land mobile, single channel narrowband operations in the 220-222 MHz band.

#### A. Transmitter Standards

1. The frequency tolerance of transmitters shall be:

| Station Class | Frequency Tolerance (ppm) |
|---|---|
| Base Station | 0.1 |
| Mobile | 1.5 |

MEASUREMENT METHOD:

A sample of the unmodulated carrier at the center frequency should be measured with equipment having an accuracy of at least five times that of the minimum to be measured.

2. Bandwidth Limitations: The maximum authorized bandwidth shall be 4 kHz.

3. Unwanted Emissions: On any frequency removed from the center of the authorized bandwidth by a displacement frequency ($f_d$ in kHz), the power of any emission shall be attenuated below the peak envelope power (P) watts in accordance with the following schedule:

| $f_d$ in kHz | | Attenuation in dB |
|---|---|---|
| | the | $30 + 20(f_d-2)$ |
| $2 < f_d \leq 3.75$ | lesser | $55 + 10\log(P)$ |
| | of | 65 |
| $3.75 < f_d$ | at least | $55 + 10\log(P)$ |

4. Resolution Bandwidth: The resolution bandwidth of the instrumentation used to measure the emission power shall be 100 Hz for measuring emissions up to and including 250 kHz from the edge of the authorized bandwidth, and 10 kHz for measuring emissions more than 250 kHz from the edge of the authorized bandwidth. If a video filter is used, its bandwidth shall not be less than the resolution bandwidth. The power level of the highest emission within the channel to which the attenuation is referenced shall be remeasured for each change in resolution bandwidth.

#### B. Geographic Separation of Sub-Band A Base Station Receivers and Sub-Band B Base Station Transmitters

Base station receivers utilizing channels assigned for sub-band A as designated in Chapter 4 will be geographically separated from those base station transmitters utilizing channels removed 200 kHz or less and assigned from sub-band B as follows:

| Separation Distances (Kilometers) | Effective Radiated Power (Watts)* |
|---|---|
| 0.0-0.3 | ** |
| 0.3-0.5 | 5 |
| 0.5-0.6 | 10 |
| 0.6-0.8 | 20 |

| | |
|---|---|
| 0.8-2.0 | 25 |
| 2.0-4.0 | 50 |
| 4.0-5.0 | 100 |
| 5.0-6.0 | 200 |
| over 6.0 | 500 |

* Transmitter peak envelope power shall be used to determine effective radiated power.

** Stations separated by 0.3 km or less shall not be authorized. This table does not apply to the low-power mobile data channels 196-200. (See Section C.)

Except for nationwide assignments, the separation of co-channel base stations shall be 120 kilometers. Shorter separations will be considered on a case-by-case basis upon submission of a technical analysis indicating that at least a 10 dB protection will be provided to an existing station's 39 dBµ signal level contour.

**C. Limitations on Power and Antenna Height:**

1. The permissible effective radiated power (ERP) with respect to antenna heights shall be determined from the follow table. These are maximum values and applications are required to justify power levels requested.

ERP vs Antenna Height Table

| **Antenna Height above Average Terrain** (HAAT) **Meters** | **Effective Radiated Power** (ERP) **Watts*** |
|---|---|
| Up to 150 | 500 |
| 150 to 225 | 250 |
| 225 to 300 | 125 |
| 300 to 450 | 60 |
| 450 to 600 | 30 |
| 600 to 750 | 20 |
| 750 to 900 | 15 |
| 900 to 1050 | 10 |
| Above 1050 | 5 |

* Transmitter PEP shall be used to determine ERP.

2. The maximum permissible ERP for mobile units is 50 watts. Portable units are considered as mobile units.

3. Channels 196-200 are limited to 2 watts ERP and a maximum antenna height of 6.1 meters (20 feet) above ground.

## 5.6 FIXED AND MOBILE/LAND MOBILE OPERATIONS

### 5.6.1 Standard for Analog or Digital FM Operations (30-50, 162-174, and 406.1-420 MHz Bands)[20]

Standards in this section related specifically to digital systems become effective on October 1, 1990.

These standards do not apply to:

o Military equipment used for tactical and/or training operations.

o FM wireless microphone systems whose mean output power does not exceed 0.1 watt.

o Equipment operating on splinter channels. (See Section 5.2.1).

o Fixed stations equipment with multi-channel emissions.

The following is for fixed and mobile/land mobile service employing fixed, land, mobile and portable stations using analog or digital FM or PM emissions in the bands 30-50, 162-174, and 406.1-420 MHz. These standards are based upon emissions with analog input and a necessary bandwidth of 16 kHz.[21]

Stations with digital input may require a different necessary bandwidth but still must meet all other standards.

**A. Transmitter**

1. Frequency tolerance ppm

| Station Class | Band (MHz) | | |
|---|---|---|---|
| | 30-50 | 162-174 | 406.1-420 |
| Land, FX | 5 | 5 | 2.5 |
| Mobile | 5 | 5 | 5 |
| Portable | 20 | 5 | 5 |

2. Unwanted Emissions: The power of any unwanted emission on any frequency removed from the center of the authorized bandwidth

(BW) by a displacement frequency ($f_d$ in kHz) shall be attenuated below the unmodulated carrier power (PZ) in accordance with the following and Figure 5.6.1.

| **$f_{d\ in\ kHz}$** | **Attenuation in** dB |
|---|---|
| 5 kHz<$f_d$≤10 kHz | 83log ($f_d$/5) |
| 10 kHz<$f_d$≤250% BW | 30-50 MHz&162-174 MHz: 29log ($f_d^2$/11) or 50 whichever is the lesser attenuation. 406.1-420 MHz: 116log ($f_d$/6.1) or 50 + 10log (pZ) or 70 whichever is the lesser attenuation. |
| $f_d$>250% BW | Land, Fixed, Mobile 50 + 10log (pZ) (i.e. 10 microwatts absolute) Portable 43 + 10log (pZ) (i.e. 50 microwatts absolute) |

**Figure 5.6.1 Levels of Unwanted Emissions**

3. Frequency Deviation for all station classes and frequency bands shall not exceed ± 5 kHz.

Measurement Method. The prescribed measurement method to be used is given in the latest revision of Electronic Industries Association (EIA) Standard RS-152, "Minimum Standards for Land Mobile Communications FM or PM Transmitters, 25-866 MHz."[19]

The present EIA measurement methods were written for analog systems. Some of these methods are not appropriate for digital systems. Appropriate analog to digital or digital to analog test sets will have to be used.

## B. Receiver

1. Frequency tolerance ppm:[22]

| Station Class | Band (MHz) | | |
|---|---|---|---|
| | 30-50 | 162-174 | 406.1-420 |
| Land, FX | 5 | 5 | 2.5 |
| Mobile | 5 | 5 | 5 |
| Portable | 20 | 25 | 5 |

2. Spurious Response Attenuation:

| Station Class | Band (MHz) | | |
|---|---|---|---|
| | 30-50 | 162-174 | 406.1-420 |
| Land, FX, Mobile | 85 dB | 85 dB | 85 dB |
| Portable | 60 dB | 60 dB | 50 dB |

3. Adjacent Channel Selectivity:

| ANALOG | | | |
|---|---|---|---|
| Station Class | Band (MHz) | | |
| | 30-50 | 162-174 | 406.1-420 |
| Land, FX, Mobile | 80 dB | 80 dB | 80 dB |
| Portable | 50 dB | 70 dB | 60 dB |

| DIGITAL | | | |
|---|---|---|---|
| Station Class | Band (MHz) | | |
| | 30-50 | 162-174 | 406.1-420 |
| Land, FX, Mobile | 50 dB | 55 dB | 55 dB |
| Portable | 50 dB | 50 dB | 50 dB |

4. Intermodulation Attenuation:

| Station Class | Band (MHz) | | |
|---|---|---|---|
| | 30-50 | 162-174 | 406.1-420 |
| Land, FX, Mobile | 60 dB | 70 dB | 70 dB |
| Portable | 50 dB | 50 dB | 50 dB |

5. Conducted Spurious Emissions:

All station classes and all bands −80 dBW Measurement Method. The prescribed measurement method is given in the latest revision of Electronic Industries Association (EIA) Standard RS-204, "Minimum Standards for Land Mobile Communication FM or PM Receivers, 25-866 MHz."[19]

The present EIA measurement methods were written for analog systems. Some of these methods are not appropriate for digital systems. Appropriate analog to digital or digital to analog test sets will have to be used.

## 5.6.2 Standards for Narrowband Operations in the 138-150.8, 162-174 and 406.1-420 MHz Bands

The standards outlined in this section apply to narrowband systems designed to operate in accordance with the timetable below and apply to all stations in the 138-150.8, 162-174 and 406.1-420 MHz bands. Reference is also made to changes made to the channeling plans and rules of use identified in Sections 4.3.7a and 4.3.9a. These standards do not apply to:

- Military equipment used for tactical and /or training operations.
- FM wireless microphone systems whose mean output power does not exceed 0.1 Watt.
- Equipment operating on channels designated for low power systems as set forth in Sections 4.3.8, 4.3.8a, 4.3.10, 4.3.10a and 5.2.1.
- NOAA Weather Radio Transmitters.
- Existing Equipment used for Command Destruct systems in the 406.1-420 MHz band.

### Effective Dates

After January 1, 1995, all new systems, and after January 1, 2005, all systems in the 162-174 MHz band must conform to these standards. After January 1, 1995, all new systems and after January 1, 2008, all systems in the 406.1-420 MHz band must conform to these standards. After January 1, 1997, all new systems and after January 1, 2008, all systems in the 138-150.8 MHz band must conform to these standards.

### Waivers

Waivers of the requirements herein may be requested when supported by reasonable justification. Waiver requests should be accompanied by technical data in support of the waiver and an explanation of the non-conforming parameters.

### Standard

The following is for fixed and mobile/land mobile service employing fixed, land, mobile, and portable stations using F3E, F1D or F1E emissions in the bands 138-150.8, 162-174 and 406.1-420 MHz with a necessary bandwidth of 11 kHz or less. The standard applies to analog and digital transmitters and receivers.

### A. Transmitter

1. Frequency tolerance ppm:

| Station Class | 138-150.8MHz 162-174 MHz | 406.1-420 MHz |
|---|---|---|
| Land, FX | 1.5 | 0.5 |
| Mobile | 2.5 | 2.0 |
| Portable | 2.5 | 2.0 |

2. Unwanted Emissions: The power of any unwanted emission on any frequency removed from the center of the authorized bandwidth (BW) by a displacement frequency ($f_d$) shall be attenuated below the unmodulated carrier power (pZ) in accordance with the following and the emission mask in Figure 5.6.2.1.

| Displacement Frq($f_d$) | Attenuation (dB) |
|---|---|
| $0 < f_d \leq 2.5$kHz | 0 |
| 2.5kHz < $f_d \leq$ 12.5kHz | 7 ($f_d$-2.5) |
| 12.5kHz < $f_d$ | 50 + 10 log (pZ)<br>or 70<br>whichever is the smaller |

3. Frequency Deviation for all FM or PM station classes shall not exceed ± 2.5 kHz for F3E emission, and ± 3.11 kHz for F1D or F1E emission using C4FM modulation with a digital transmission rate of 4800 symbols per second.

4. Measurement Methods. The measurement methods to be used are described in the Telecommunications Industries Association (TIA) standard TIA/EIA-603 for F3E emission equipment and Telecommunications Systems Bulletin TIA/EIA TSB102.CAAA for F1D or F1E emission equipment as adopted by NTIA. Where these methods are not specified for a particular system type, appropriate test procedures should be applied.

**B. Receiver**

1. Frequency tolerance ppm:

| | 138-150.8 MHz | |
|---|---|---|
| **Station Class** | **162-174 MHz** | **406.1-420 MHz** |
| Land, FX | 1.5 | 0.5 |
| Mobile | 2.5 | 2.0 |
| Portable | 2.5 | 2.0 |

2. Spurious Response Attenuation:

| | 138-150.8 MHz | |
|---|---|---|
| **Station Class** | **162-174 MHz** | **406.1-420 MHz** |
| Land, FX | 70 dB | 70 dB |
| Mobile | 70 dB | 70 dB |
| Portable | 60 dB | 60 dB |

3. Adjacent Channel Selectivity:

| | 138-150.8 MHz | |
|---|---|---|
| **Station Class** | **162-174 MHz** | **406.1-420 MHz** |
| | F3E/F1D/F1E | F3E/F1D/F1E |
| Land, FX | 70/60 dB | 70/60 dB |
| Mobile | 70/60 dB | 70/60 dB |
| Portable | 60/50 dB | 60/50 dB |

4. Intermodulation Rejection:

| | 138-150.8 MHz | |
|---|---|---|
| **Station Class** | **162-174 MHz** | **406.1-420 MHz** |
| Land, FX | 70 dB | 70 dB |
| Mobile | 70 dB | 70 dB |
| Portable | 50 dB | 50 dB |

5. Conducted Spurious Emissions: -57 dBm

6. Measurement Methods. The measurement methods to be used are described in the latest Telecommunications Industries Association (TIA) standard TIA/EIA-603 for F3E emission equipment and Telecommunications Systems Bulletin TIA/EIA TSB102.CAAA for F1D or F1E emission equipment as adopted by NTIA. Where these methods are not specified for a particular system type, appropriate test procedures should be applied.

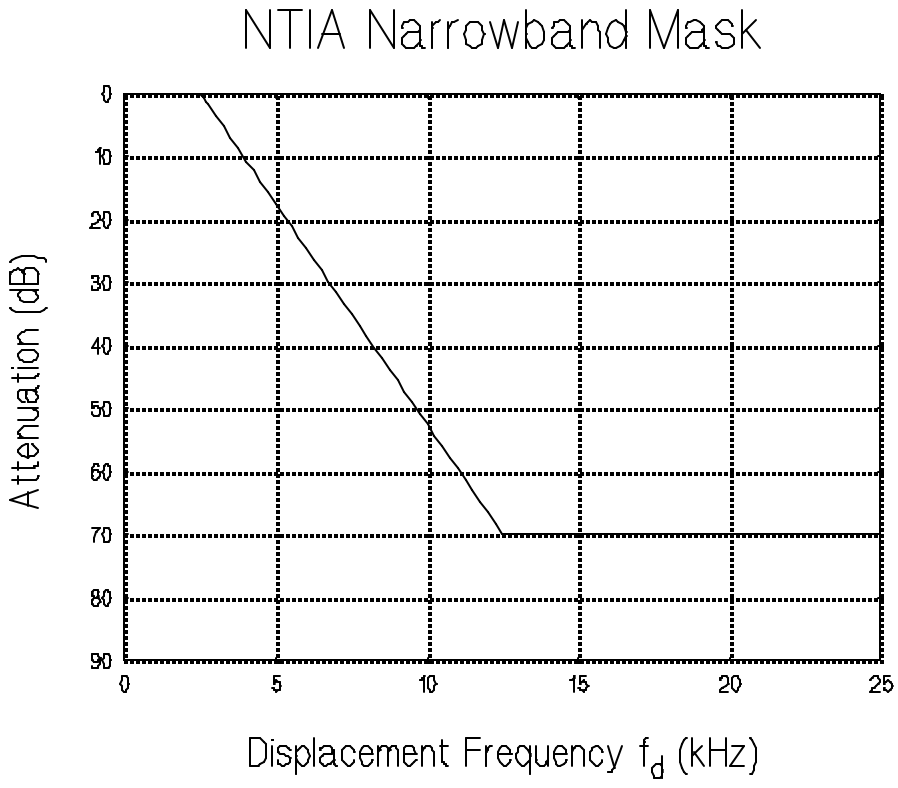



**Figure 5.6.2.1 LEVELS OF UNWANTED EMISSIONS**

Note: This emission mask represents the TIA emission mask developed for narrowband FM and Digital systems designed to operate in 12.5 kHz channels in the bands 138-150.8 MHz, 162-174 MHz, and 406.1-420 MHz.

## 5.7 SPACE SERVICES

### 5.7.1 Standard for Unwanted Emissions for the Space Services (Effective 1/1/85)

These standards shall be equalled or exceeded in space systems initially submitted for systems review (Chapter 10) after the effective date.

The requirements in this standard specify the upper bounds on unwanted emissions from space and earth stations associated with the space services. They promote electromagnetic compatibility among space systems and between space systems and systems of other services

sharing the spectrum. These requirements simplify the planning and evaluation of system requirements by limiting the envelope of the emitted spectrum to maximum spectral power density (SPD) levels below. (See Figure 5.7.1)

Since this standard cannot be used alone for planning and evaluation purposes, it is emphasized that the modulation type, emission spectrum, power output, frequency tolerance, and maximum expected doppler shift should be considered and provided in accordance with Chapter 10 of this Manual. These requirements are applicable to U.S. Government space systems including associated earth terminals operating in all portions of the spectrum allocated to the space services above 1 GHz. They do not apply to transmissions from radars on the ground or aboard spacecraft.

**A. Transmitter Standard**

1. Frequency Tolerance (See Part 5.1).

**Figure 5.7.1. Maximum Unwanted Emission Levels For Space Services**

## 5.8 TELEMETRY, TERRESTRIAL (1435-1535 MHz, 2200-2290 and 2310-2390 MHz)

These standards are applicable to terrestrial telemetering stations, authorized for operation in the bands 1435-1535, 2200-2290 and 2310-2390 MHz.

### 5.8.1 Transmitter Standards

1. Frequency Tolerance (See Part 5.1).

2. Unwanted Emissions.

a. For Authorized Bandwidth equal to or less than 1 MHz, the emissions must be attenuated below the mean power of the transmitter (pY) as follows:

(1) On any frequency removed from the assigned frequency by more than 100 percent of the authorized bandwidth up to and including 100 percent plus 0.5 MHz, the attenuation must be at least 60 dB, when measured in a 3.0 kHz band-width. This signal need not be attenuated more than 25 dB below 1 milliwatt.

(2) On any frequency removed from the assigned frequency by more than 100 percent of the authorized bandwidth plus 0.5 MHz, the attenuation must be at least $55 + 10 \log_{10}$ pY dB, when measured in a 3.0 kHz bandwidth.

b. For Authorized Bandwidth greater than 1 MHz, the emissions must be attenuated below the mean power of the power of the transmitter (pY) as follows:

(1) On any frequency removed from the assigned frequency by more than 50 percent of the authorized bandwidth plus 0.5 MHz up to and including 50 percent of the authorized bandwidth plus 1.0 MHz, the attenuation must be 60 dB, when measured in a 3.0 kHz bandwidth. The signal need not be attenuated more than 25 dB below 1 milliwatt.

(2) On any frequency removed from the assigned frequency by more than 50 percent of the authorized bandwidth plus 1.0 MHz, the attenuation must be at least $55 + 10 \log_{10}$ pY dB, when measured in a 3.0 kHz bandwidth.

## Endnotes for Chapter 5

1. These frequency pairs are shared between Government and non-Government users. Power constraints placed on the frequency pairs facilitate coordination due to the decreased interference potential.

2. Primary Radar: A radiodetermination system based on the comparison of reference signals with radio signals reflected from the position to be determined. (No. 95 of the ITU Radio Regulations, 1982 Edition.)

3. Spacebased Radiolocation System--Class 1: a radiolocation system in space the primary function of which is the detection and location of objects on or near the surface of the Earth.

4. Spacebased Radiolocation System--Class 2: a radiolocation system installed aboard a spacecraft for the purpose of determining the relative positions or velocities of one or more extravehicular objects.

5. Active Spaceborne Sensor--a measuring instrument in the Earth Exploration Service, or in the Space Research Service, by means of which physical measurements of various phenomena are obtained through transmission and reception of radio waves.

6. Man-portable: Items which are designed to be carried as a component part of individual, crew-served or team equipment in conjunction with assigned duties. These items are nominally less than 15 kilograms (32 pounds).

7. Man-transportable: Items which are usually transported on wheeled, tracked or air vehicles but have integral provisions to allow periodic handling by one or more individuals for limited distances (i.e., 100-500 meters). These items are nominally less than 30 kilograms (65 pounds).

8. These formulas yield the total composite B(−40dB) bandwidth of a frequency hoping radar as if all channels included within $B_s$ were operating simultaneously. Individual channels will have a B(−40dB) radar emission bandwidth given by 3.1 or 3.2 above. For frequency hopping radars, the radar spectrum shall not intrude into adjacent spectrum regions on the high or low side of the band, defined by $B_s$, more than would occur if the radar was fixed tuned at carrier frequencies equivalent to the end values of $B_s$ and was complying with the constraints of 3.1 and 3.2 above.

9. If $t_f$ is less that $t_r$, as defined in Part 5.3, $t_f$ is to be used in place of $t_r$ when performing the emission bandwidth calculations.

10. These formulas yield the total composite B(−40 dB) bandwidth of a frequency hopping radar as if all channels included within $B_s$ were operating simultaneously. Individual channels have a B(−40 dB) radar emission bandwidth given by 3.1 or 3.2 above. For frequency hopping radars, the radar spectrum shall not intrude into adjacent spectrum regions on the high or low side of the band, defined by $B_s$, more than would occur if the radar were fixed tuned at carrier frequencies equivalent to the end values of $B_s$ and was

complying with the constraints of 3.1 and 3.2 above.

11. Median gain is defined as that level over an angular region at which the probability is 50% that the observed or measured gain at any position of the antenna will be less than or equal to that level.

12. These formulas yield the total composite B(−40 dB) bandwidth of a frequency hopping radar as if all channels included within $B_s$ were operating simultaneously. Individual channels will have a B(−40 dB) radar emission bandwidth given by a. or b. above. For frequency hopping radars, the radar spectrum shall not intrude into adjacent spectrum regions on the high or low side of the band, defined by $B_s$, more than would occur if the radar were fixed tuned at carrier frequencies equivalent to the end values of $B_s$ and was complying with the constraints of a. and b. above.

13. Median gain is defined as that level over an angular region at which the probability is 50% that the observed or measure gain at any position of the antenna will be less than or equal to that level.

14. In other than exceptional cases the practice is to authorize 3 kHz as the necessary bandwidth for normal voice intelligibility. This is specified by the emission designator. In the practical case, to meet the minimum performance requirements of this paragraph the roll-off of the emission curve will begin at a value somewhat less than 1.5 kHz form the assigned frequency.

15. Passband. The passband is the band of frequencies limited by the two frequencies for which the voltage is attenuated to one-half of the voltage of the most favored frequency.

16. Applies to both transmitting and receiving antennas, but to the latter only when protection from harmful interference is required.

17. These figures would be approximately 6 dB greater if the gain were to be expressed relative to an isotropic antenna in free space, in order to account for ground reflection.

18. It is recognized that relatively narrowband digital radio systems may be unduly restricted by this standard. Work is in progress to define appropriate limitations for such narrowband systems. This standard will be modified in accordance with the findings and experience with such narrowband systems.

19. Copies of these standards may be obtained from the Electronic Industries Association, 2001 Eye Street, N.W., Washington, D.C. 20006.

20. In the band 406.1-410 MHz, power is limited to a maximum of 7 W/kHz of necessary bandwidth as specified in footnote US 117.

21. The spacing of channels (adjacent channel spacing) is 20 kHz in the 30-50 MHz band and 25 kHz in the 162-174 and 406.1-420 MHz bands.

22. Measurement Method -- An unmodulated standard input signal source, adjusted to the standard input frequency as specified in EIA RS-204, shall be connected to the receiver under test and adjusted for an output of 20 dB above the receiver sensitivity. The center frequency of the IF passband shall be measured with equipment having a degree of accuracy of at least five times the minimum tolerance to be measured.

**(Last page in Chapter 5)**